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KENTUCKY GEOLOGICAL SURVEY

Charles J. Norwood, Director.

REPORT

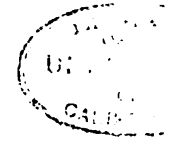
ON THE

Progress of the Survey,

FOR THE YEARS 1904 AND 1905,

By CHARLES J. NORWOOD.

Lexington, Ky.



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1905

KENTUCKY
GEOLOGICAL SURVEY

(1904-1918)

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LETTER OF TRANSMITTAL.

To His Excellency, J. C. W. BECKHAM

Governor of Kentucky.

Sir:—I have the honor to submit the following report on the progress of the Geological Survey of the State since the revival of the work in March, 1904, up to date.

Very respectfully,

CHARLES J. NORWOOD,
Director, Kentucky Geological Survey.

LEXINGTON KY. December 1, 1905.

316258

REPORT OF PROGRESS.

It will be remembered that the field work of the Survey was suspended in 1892, and the affairs of the office placed in the hands of the State Inspector of Mines as Curator. I believe it is now very generally recognized that the long suspension of the work has proven most unfortunate for the State, hence it is not deemed necessary to enter into the particulars of wherein Kentucky has, during most momentous years of industrial movements, been at a disadvantage in comparison with her sister States that have maintained their Surveys during all the years and have continuously issued bulletins relating to their economic resources. In the years preceding the suspension, as is known by those conversant with the facts, the Survey achieved great results in forwarding the development of the State. Equally as good results will follow the revival, if the latter be not too brief; indeed, in consequence of the formation of commercial clubs and similar organizations, throughout the State, now going on more generally than ever before, with which the Survey may co-operate, we may expect speedier and more effective results from the Survey's work than was possible hitherto.

A history of the operations of the Survey under the administrations of Prof. N. S. Shaler and Mr. J. R. Procter, with summaries of results, will be found in another report now in course of preparation. A detailed discussion of the work accomplished by the present organization is also reserved for that report.

The law which governs the present Survey provides for the study of our resources first by subjects, instead of by regions as hitherto. This plan, which is esentially the same as one which Prof. N. S. Shaler had in mind at about the time he retired from the directorship of the Survey, in 1880, will prove most satisfactory to those seeking information on some particular subject, and it will, of course, carry the Survey the more speedily into all the counties as the investigation of each subject proceeds. It may be well to here quote the two sections of the law relating to this matter. They are as follows:

"Section 5. It shall be the duty of the Director of the Survey and his assistants to examine, study and report upon the economic geology of the State especially, giving particular attention to such mineral resources as coal, iron, lead, zinc, barite, fluorite, clays, shales, building stones, asphalt rock, road and paving materials, salt, cement materials, natural fertilizers, petroleum, natural gas, pigment earths, abrasives, marbles, lithographic stones, and other minerals; determining their location and extent, which shall be shown on appropriate diagrams and maps, their relations to transportation routes, actual and possible, and their chemical and physical qualities to such extent as may be necessary in each case; and such investigations shall be conducted along such lines as will prove of practical value in ascertaining and exhibiting the fitness for commercial uses of the various substances reported upon, and shall include such standard and practical tests as are necesary and usual in determining the commercial values of the various materials under investigation. The occurrence of mineral springs shall also be noted and the waters analyzed when necessary, and the water powers of the State shall be investigated. The soils of the State shall also be studied, with reference to their fitness for various classes of crops, with a view to determining the proper fertilizers for impoverished ground, and such results as are appropriate shall be embodied in a soil map. The character and distribution of the timbers of the State shall also be determined.

"Sec. 6. In furtherance of the object sought to be attained by this act, and in order that the results of the Survey may be presented in most convenient form, the reports of the Survey shall be divided into three classes, namely (1) Subject Reports, (2) County Reports, (3) General or Index Report. (1) The subject reports shall consist of a series of special economic reports issued as bulletins, each report dealing with some particular mineral occurrence, or particular subject, such as enumerated in section 5, and treating it in an exhaustive way, with reference to its occurrence throughout the State as a whole; but in cases where the occurrence of any one mineral is limited in amount or extent, or where two or more mineral occurrences may more appropriately be treated together, then a bulletin may be issued including more than one subject. To carry out the

provisions of this section, therefore, there shall be issued a special report on the coals of the State, which may be divided into two parts, one on the coals of the Eastern Field, and one on those of the Western Field; a similar report on the clays, shales, and cement materials of the State; one on the building stones and marbles; one on the lead and zinc ores, and the barite and fluorite deposits; one on petroleum and natural gas; one on asphalt rock and road materials, and so on, appropriate bulletins being issued with reference to the various subjects of investigation coming within the province of the Survey, the results of the soil survey being published in the form of an agricultural bulletin. Said reports shall be accompanied by all diagrams and illustrations necessary to render them full and complete. In order that the results of the Survey may be given to the public as expeditiously as possible, the bulletins herein provided for shall be the form of publications to be issued first, and in cases of urgency the director may issue preliminary parts of a bulletin, covering the special work so far as it has progressed, in advance of the completion of the entire bulletin. (2) The county reports shall consist of full and complete reports on the mineral, agricultural, and other natural resources of the county, accompanied by maps and diagrams showing the geological formations of the county, with their dips and flexures, and such items of topography as the resources of the survey will permit. (3) The general report shall relate to the distribution of the geological formations and mineral resources of the State as a whole, its purpose being to present a general view of the natural resources of the State, and to serve as an index to the occurrences of the mineral deposits and distribution of timbers by citations to the special bulletins and county reports wherein extended descriptions of the same may be found."

PERSONNEL OF THE SURVEY.

The following persons are now, or have been, employed on the Survey, named in the order of their appointment under each class:

Director.—Charles J. Norwood.

Assistants in Geology.—Joseph B. Hoeing, Arthur M. Miller, Aug. F. Foerste, W. F. Pate, Albert R. Crandall, James H. Gardner, Samuel A. Denny, F. Julius Fohs, John M. Nickles (temporary).

Miscellaneous.—Alfred M. Peter, chemist; John E. Wright, mining assistant (term of service expired); Moritz Fischer, geologic assistant (temporary); Robert H. Barclay, mining aid (term of service expired); George V. Triplett, Jr., aid (resigned); Curtis L. Jones, secretary (resigned); W. U. Grider, assistant in charge of building stones (resigned).

Topographic.—Joseph G. Lewis, topographic assistant (resigned); Joseph S. Shaw, topographic assistant; R. E. Mooreman, draftsman (temporary). Temporary Aids: Oscar R. Kroell, Hargis Hill, Charles G. Montgomery, Boyd M. Sims, Kay K. Kevil, William W. Shelby, Jr.

Temporary Aids in Geology.—Charles R. Gilmore, W. C. Payne, John Goff.

Field work began in April, 1904, shortly after the Survey act became a law, and has been pushed vigorously. Two reports, with maps, have been printed, six are now in the hands of the printer, and several are in course of preparation. A list of all reports is given on a succeeding page.

OIL AND GAS.

A bulletin on the oil and gas sands of the State, prepared by Mr. J. B. Hoeing, has been printed. The report sheds light on a number of things that hitherto have not been understood in Kentucky. It has been learned, for instance, that, contrary to views held hitherto, we have important oil horizons in the "Trenton" (so-called), which gives to that formation, where deep-seated, with favorable structural conditions, a value in Kentucky not heretofore recognized; also, that there are promising gas horizons in the deep-lying Calciferous, which thus gives to a large territory a possible value (justifying prospecting) not hitherto suspected. The large number of well records given in the report will prove of service to drillers when prospecting for oil or gas. Following is a list of the oil and gas horizons, given in their vertical order, reading downward, as defined in the report:

1. In the Conglomerate Series of the Coal Measures:

Beaver, Horton, Pike, Salt, } of Floyd, Pike, Knott, etc.

Wages, Jones, Epperson, } Knox County.

2. In the St. Louis Group:

In Pike and Martin Counties.

3. In the Waverly and Keokuk-Waverly:

Big Injun Group.
Cloverport Gas.

Stray.....

Amber of Barren.

Mt. Pisgah
Beaver, Otter, Cooper, Slickford, } of Wayne.....

Berea Grit.

4. In the Devonian:

a. Black Shale.....Gas Sand of Meade.

b. Corniferous.....{ Ragland Oil, Irvine Oil, Menefee Gas.

5. In the Upper Silurian:

a. Niagara.....Boyd's Creek of Barren.
b. Clinton.....Clinton of Barren, Wolfe, Morgan, etc.

6. In the Cincinnatian (Hudson of Linney):

"Upper Hudson"..... { Caney of Morgan. Upper Sunny Brook.
"Lower Hudson"..... { Barren County. Cumberland County.

7. In the Mohawkian (Trenton of Linney):

Trenton (Lexington) Limestones.....Lower Sunnybrook.
Highbridge (including "Birdseye" and "Chazy" of Linney)..... { Barren, Wayne, Clinton and Cumberland Lower Sands.
Knox Dolomite.....Deep Sand of Wayne.

8. In the Calciferous:

Saltwater Sand at Top.
Gas Sand in Estill County.

It should be said that the systematic study of our oil possibilities is no more than fairly well begun. The project for the further prosecution of the work includes an underground survey of the oil horizons, and the charting of the dips of the rocks throughout the State. This will reduce the uncertainties of wild-catting. In view of the growing disposition to use natural gas and oil for fuel in this State, and of the value that stores of such fuels have in determining the establishment of manufacturing industries, the importance of continuing this line of investigation in a thorough way is manifest. It is hoped that as the work progresses, tests under intelligent supervision may be made in the Jackson's Purchase region. The finding of fuel gas in that great clay region would prove of incalculable benefit to the district. It may be remarked here, in connection with the reference to supervision of the drilling of wells for gas and oil, that in a number of instances the Survey has been called upon to furnish a man to watch the drilling of wells and keep accurate records of the strata pierced. Since, as is well known by those familiar with the work, it is most difficult to obtain

accurate records and samples of the drillings from the "practical" driller who has immediate charge of the machine, the requests would have been complied with gladly had it been feasible to do so, but the limitations on the expenditures of the Survey in consequence of the comparatively small fund at command rendered it impossible.

CENTRAL KENTUCKY LEAD, ZINC AND SPAR DEPOSITS.

I think it beyond question that the mineral veins of this district afford the basis upon which may be established important commercial enterprises. The veins, of which there is a remarkable number, very many of them of easily workable width, fall into three classes as regards composition, namely, those consisting of barite with variable amounts of galena and some sphalerite (zinc sulphide); those in which the filling is fluorite, either essentially in whole or in larger part; and those composed of calcite, in some places carrying considerable percentages of sphalerite (as on Twin creek, Owen county), and in others quite free from metalliferous content so far as at present known, as in the case of the great calcite vein of Mercer county.*

A thorough examination of these hitherto little known and practically neglected sources of industrial wealth was, therefore, deemed one of the most useful lines of investigation to which the early attention of the Survey might be given, and a bulletin on the lead and zinc-bearing rocks of Central Kentucky, by Prof. A. M. Miller, has been printed.

Though the chief purpose of the report is to describe the strata in which the veins occur, a proper classification of the rocks be-

*It may be, however, that these distinctions are seeming rather than real; that the differences in mineral content are a matter of vertical distribution; and that whether a vein shall show barite, or calcite, or fluorite as the filling matter depends upon whether the outcrop represents a higher, or intermediate, or lower section of the vein. This is one of the problems concerning which sufficient data have not been gathered, but it is a determined fact that barite prevails in veins as they pass through the Lexington, from the Winchester beds down to the Tyrone ("Birdseye") of the Highbridge; that as they pass from the Lexington into the Tyrone calcite and fluorite begin to predominate; and that from near the top of the Tyrone down into the Campnelson ("Chazy") as far as the latter has been penetrated, fluorite and calcite prevail.

ing necessary for an intelligent study of the mineral deposits, the bulletin will prove very useful to prospectors. The report shows, among other facts, that the Central Kentucky veins are continuous from the top of what is usually known in Kentucky as the Trenton (now defined as Lexington) far down in the lowest rock that is exposed in the State; and that within the Bluegrass area are large deposits of the finest of fluorspar, whereas not even the mere existence of that mineral was known there a few years ago.

There is warrant for the expectation that the barite deposis of this district will of themselves prove the basis for important industrial establishments, the chief object of which will be the production of ground barite and of barium salts. Already the Mutual Mining Company, of Stamping Ground, Scott county, is engaged in the manufacture of refined (precipitated) barium sulphate, lead fume, and various by-products, and the Monitor (formerly Chinn) Mineral Company, of Mercer county, is preparing to mine and prepare for market its extensive barite, calcite, and fluorite deposits upon a large scale. Mines are in operation in Henry and Owen counties, in the galena-bearing barite veins there. In these counties hitherto only galena has been produced for market, but it is understood that the barite will hereafter be an important product.

In order that the development of these Central Kentucky deposits may be undertaken in an intelligent way, however, it is necessary that a careful study of the veins themselves shall be made throughout the district, so that guiding facts of general application may be determined. With that end in view, Mr. J. E. Wright, mining assistant, was assigned to work in the district in April, 1905, the field assignment continuing until August 1st. In this work the Director has borne a part and has in hand the preparation of a report which will be completed when sufficient additional data shall have been gathered. Another season will be required to complete the work, since the deposits have proved to be more numerous and of more importance, and to be distributed over a larger number of counties than was supposed to be the case.* Mr. Wright has presented

*In addition to the counties forming what is known as Central Kentucky, certain counties on the east and Cumberland county to the south are yet to be examined.

a short statement of his observations, which will be printed in the report of the Inspector of Mines for 1905, the briefness of the report rendering it somewhat impracticable to issue it as a separate bulletin. Some important facts hitherto not known to be generally applicable to the district—such as the almost, if not quite universal, relation of the veins to faults—and which make for the greater economic importance of the deposits, have been discovered. Specimens of zinc carbonate of high quality, hitherto unknown in this district, were found by Mr. Wright, in Bourbon county, suggesting a chance that deposits of commercial value may be discovered.* Zinc carbonate (altered sphalerite) has also been found by the writer in Woodford and Jessamine counties.

The deepest shaft, geologically, in the State is that of the "Twin Chimneys" mine of the Monitor (formerly Chinn) Mineral Company, in Mercer county. There a banded fluorite vein, 4 to 5 feet in width, has been followed down to a depth of 245 feet in the Campnelson ("Chazy"), with no indications of any tendency of the fissure to close. When visited recently, in November, water prevented an examination of the bottom of the shaft, but at a point about 20 feet above the bottom measurements were made showing 53 to 63 inches of vein matter. It was claimed by men working in the shaft that at the bottom the vein showed 4 feet of clean fluorspar. The developments in these lower rocks in Mercer county are instructive to those mining or who may undertake mining in other parts of the Central region, where the "Chazy" is deeply covered. They afford encouragement to those mining in the vicinity of Lockport, Henry county, and Gratz, Owen county, for instance. At Gratz the vein has been followed down to and into the Tyrone ("Birdseye") formation, and because of some eccentricities exhibited by the fissure in the Tyrone questions were raised as to the continuation of the vein downward. There seems to be no good reason to doubt that the vein continues downward, if geologic

*It seems well to here correct an error that appears in Dana's Mineralogy, and is quoted in Merrill's "Nonmetallic Minerals," namely, the reported occurrence of witherite (carbonate of barium) "near Lexington, Kentucky." Although searched for through many years, ever since the first appearance of the note in the Mineralogy, no witherite has been found in this region.

conditions affecting the Campnelson are similar to those farther up the river, though there may be a change in the vein-stuff.

WESTERN KENTUCKY LEAD, ZINC AND SPAR DEPOSITS.

Mr. F. Julius Fohs spent the season of 1905 in the study of the lead, zinc, and spar regions of Western Kentucky. With him was a mapping party* to accurately locate all mines, prospects, faults, and veins. In 1902 the U. S. Geological Survey, acting in co-operation with the Curator of the Kentucky Geological Department, in whose hands a small sum for the purpose had been placed by citizens of the district, made an examination of the region and the report was issued in August of the present year. With propriety, the claim may be made in behalf of the Kentucky Survey under the administration of the late John R. Procter for a large share in the work upon which the report is based, since the larger part of the field work of Mr. Ulrich, who had charge of the examinations made by the Federal organization in 1902, was done in 1889 and 1890, when that gentleman was a member of the State Survey. Had the report been issued earlier, it would have been of advantage to us in the prosecution of our investigations. That there was need for the State Survey work, and that without conflicting with what had been done by the Federal organization, will appear when our reports are issued.

In addition to a report on the district as a whole, Mr. Fohs will present one on the mineral veins and other resources of Livingston county; the latter will be ready for the printer at an early day.

It was originally intended that the Livingston report should be only a revision (bringing it to date) of the manuscript report made by Dr. R. H. Loughridge—one of the four manuscript reports left in the archives of the Survey when appropriations ceased in 1892, to which reference is made on a succeeding page, the publication of which was authorized by the present Survey law. The discovery of new facts, etc., during the progress of the field work in revision, however, rendered so many additions and modifications necessary that Mr. Fohs will present a practically new report.

*Headed by Mr. J. S. Shaw.

According to the observations of Mr. Fohs, the Livingston county deposits have the same general character as those of Crittenden; they have the same possibilities so far as regards intrinsic values, the difference between the two regions with respect to possibilities of development being chiefly one of transportation. Some faults hitherto unknown were discovered in the progress of the field work, the probabilities being that at least a number of them are ore-bearing near the surface, and that all of them are so at depth—below the sandy horizons. The report, which is nearing completion, contains descriptions of all the mines and "prospects" (about 60) in the county, and of the mills. Methods of mining, ore-dressing, etc., are described, and the geology and veins are laid down on maps.

The general report will include the following counties:

Livingston.—All details of geology, mines, prospects, etc.

Crittenden.—All details of geology, mines, prospects, mills, etc. In this county there are 120 mines and prospects.

Caldwell.—Practically all mines and prospects are described, together with considerable of the geology. Part of another season of field work will be required for the completion of the geology.

Lyon.—Some notes on the geology will be given. There are chances for the occurrence of lead, zinc and spar deposits in this county, but there was not sufficient time at command in which to make a thorough examination with respect to them. Another season of work and close search will be required to develop the facts.

Trigg.—Notes on all the mining prospects. There are a great number of shear zones in this county, and the chances for finding ores and spar are good. So far, the prospecting in the county has not been conducted on the best lines.

Christian.—Some notes on this county.

It seems well to here briefly present some facts in regard to the district as developed by the work of the Survey.* It has been noted:

1. That large calcite bands, 3 to 12 feet wide, appear on the

*Statistics of production for 1903 and 1904 will be found in the report of the State Inspector of Mines for 1904.

walls of some of the larger (more valuable) veins. Since a growing market for calcite has developed, this fact is of commercial as well as of scientific interest. Some shipments of that spar have been made from the district.

2. The barite in the district is associated less with the fluorspar in the large faults than with that in the smaller veins that show little or no faulting and have one or both walls of limestone. The value of this "pointer" will be recognized by mining men.

3. There is little change in the character of the fluorspar deposits with depth other than that which is to be expected in unweathered mineral, and except such as goes, *pari passu*, with the changes of wall rock.

4. The chances for the discovery of new and large bodies of zinc carbonate (as a reconcentration) along large faults where St. Louis limestone forms one wall, if the prospecting be done on the St. Louis side of the fault, are good. Further prospecting for zinc carbonate is encouraged.

5. The character of the fluorspar largely depends on the inclosing rock and manner of formation (genesis) of the spar. This is illustrated by the following examples: "No. 1 fluorspar" (the highest grade) has either Princeton (Ste. Genevieve of Ulrich) or Tribune limestone for one or both walls, largely, when filling fissures. Coarse, dark or brown fluorspar is in large measure associated with bituminous shale walls, and at times it carries a large amount of coarse, crystalline sphalerite. Finer grained, dark colored fluorspar is usually associated with jasperoid, and occurs as a replacement either of Princeton or St. Louis limestones, principally the former; and it is largely associated with fine-grained zinc and small cubical or granular galena. Purple fluorspar, though it occurs more or less in surface deposits, is largely to be found in the St. Louis limestone and in gravel deposits. Gravel fluorspar is in nearly all cases practically in place, and the solid deposits are to be found by sinking on them.

6. The coarser lead ore (galena) is largely associated with white fluorite, while the small cubical and granular varieties are replacement deposits. A body of almost solid galena, 3 feet in width, has recently been found at the Mary Belle mine, on the Columbia tract, at a depth of 40 feet.

7. The largest ore bodies constitute replacements of wide sheeted zones, while the narrower ones are fillings of fissures.

8. The chances for finding zinc deposits are better in sheeted zones parallel with the veins than in the fluorspar deposits, the latter generally occurring nearer the fault plane. On this account, the small amount of cross-cutting that has been done from the veins has prevented the discovery of many zinc deposits. There is reason to believe that the disposition of fluorspar prospectors to cover up the discovery of zinc, and do little searching for it, on account of its undesirability in association with fluorspar, has greatly retarded the opening of probably a large number of deposits of this character. Zinc deposits in the sheeted zones, while carrying some fluorspar, have not as much of that mineral as have those directly at the fault or in the veins.

9. The chances for the discovery of new fluorspar and lead deposits along undeveloped, or partially developed, fault zones are good.

10. A number of clay deposits of the "Stevens Tunnels" type —rather a firesand than a fireclay, of which large quantities are shipped from Stevens Tunnels—were found, with chances for more. This product has naturally the same constituents as Dinas brick, and so is a first-class material.

The quantity of fluorspar in this district is enormous. But few of the opened veins are worked out for as much as even 100 feet below water level, and below that depth the products appear to be the same. The popular idea as to the small amount of zinc in the district appears to be erroneous. A new custom concentrating plant, for the separation of the zinc and lead, is being erected, but its precise character (the method to be followed) is not known.

FAULTS SOUTH OF THE WESTERN COALFIELD, ETC.

An examination of the faults and fractures lying south of the known lead, zinc, and spar region in Western Kentucky, and south of the Western Coalfield, to ascertain whether any of them carry ores or fluorspar, was undertaken in 1904. The work

was placed in the hands of Mr. J. E. Wright, the present writer also rendering aid in the investigation. Mr. Wright presented a brief, but interesting, report of his work, the conclusive parts of which will be included in the detailed report on the region traversed. It was determined that most of the fractures do not carry ores or fluorspar within easy reach from the surface, but that possibly some of them do. What may be found at depth on some of the strongest faults can be determined only by deep prospecting. Unfortunately, some of the most important prospecting that has been done along the faults has not been done in the true fault planes, or by systematic cross-cuts at depth, but in the bed planes of dipping rocks.

CHEMICAL WORK.

A bulletin of chemical analyses is in the hands of the printer. This bulletin includes all the unpublished analyses that had been made for the Kentucky Survey by the late Dr. Robert Peter, worked out and properly arranged by his son, Dr. Alfred M. Peter, present Chemist of the Survey, together with many additional ones. Analyses of many samples of clay, coal, stone, etc., collected by the present organization, have been made by Dr. Alfred M. Peter, and a few analyses of clay were, in an emergency, made by other chemists. These analyses, not sufficient in number to warrant the publication of another chemical bulletin, have been used in reports now ready or in course of preparation.

CLAY DEPOSITS.

My confidence in the future of Kentucky as a clay-producing State grows as more is learned about our deposits, but we must meet the requirements of clay-workers by proving the worth of the clays by technical tests before we can hope to make much progress with them. The means at the command of the Survey have not been sufficient to undertake such work. Among others, there are two reasons why every possible effort should be made to promote the development of our clay resources—one

sociological, and the other purely commercial; they are, first, the well-settled fact that clay-working communities are among the most stable of those that are made up most largely of "laboring" classes, with the further fact that since a large part of the "labor" used need have only simple skill, readily acquired, clay-working plants would give employment to a numerically important element of our population, including women, youths and girls, whose lives now hold but little in the way of a hopeful future; and, second, clay-working industries will call for a greater development of our coalfields.

The most the Survey has been able to do within the time that has been at our disposal, and with the comparatively small sum that could be allotted for the work, has been to gather data for a preliminary bulletin, which should show the locations, thicknesses and general qualities of some of our clay deposits, and give us a better standing with the clay industries than we now have, until technical work may be taken up hereafter. Such a bulletin has been prepared and is in the hands of the printer.

The report is in three parts. Part I., by Mr. J. H. Gardner, includes the kaolins and plastic clays adjacent to the eastern rim of the Western Coalfield, embraced in the counties of Hart, Hardin, Edmonson, Grayson, Taylor and Larue; clays in the Red river valley; and clays of the Jackson's Purchase region. Also a statement by Mr. F. J. Fohs concerning the clays in the region between the Cumberland and Tradewater rivers. Part II., by Prof. A. F. Foerste, is an extract from another report by him, and is a discussion of the clays and limestones of the Silurian, Devonian, Waverly and Irvine formations of East-Central Kentucky. Part III. includes a compilation by Mr. J. H. Gardner of all available analyses of clays that have been collected from various counties of the State. It is believed that this bulletin, although it may be regarded as only a beginning of the study of our clays, will prove of much service to those interested in clay-working and cement-making industries. One of the direct results of the work of the Survey in the Red River Valley is the assurance that a large Portland cement plant will be established there. While in the newspaper accounts of the proposed enterprise the Survey's part in promoting it is not mentioned, it is nevertheless the fact that the movement to es-

tablish the plant is due to discoveries and advice and suggestions first made by the Survey.*

*Since the foregoing was written, a letter has been received from Mr. J C. Patrick, who has been most active in securing the establishment of the plant (representing perhaps $100,000), in which due credit is given the Survey. The letter is as follows:

"STANTON, KY., December 15, 1905.

"*Mr. C. J. Norwood, Director of Kentucky Geological Survey, Lexington, Ky.:*

"DEAR SIR—Recent editions of Lexington and Louisville papers, purporting to give interviews with me, have given out the impression to the public that the major share of the credit of finding and developing the cement material in this region is due to Ohio talent. I therefore feel it my duty to acknowledge to you my indebtedness to the Kentucky Geological Survey, and make known the part they had in the discovery and development of these deposits. The existence of clay and limestone at this place suitable for the manufacture of Portland cement was discovered by Assistant Geologist Gardner. This discovery was made in the course of his routine work in this valley. Afterwards, Mr. Gardner and I went over the ground more thoroughly, and he pointed out the clay and stone to me, and gave me instructions as to how to proceed in testing and developing same.

"Mr. Gardner suggested that since the Kentucky Survey was unable to test these materials, on account of lack of the proper apparatus and laboratories, the clay and stone should be sent to the Ohio Geological Survey for testing. With this end in view, he opened correspondence with the Ohio Survey, with the result that I was enabled to send my material there for testing. The results of these tests are pretty well known now, but I herewith send you a copy of the report on same, in the hope it may be of some value to you in your work.

"I wish to especially thank you and Mr. Gardner for your assistance in this undertaking, because its success is to a very large extent due to your valuable aid and suggestions; and in order that every one concerned may be informed of the true history of the matter, I give you leave to use this communication as you may see proper. With kindest regards, I am,

"Very truly yours,

"J. C. PATRICK."

The report of Mr. C. G. Holmes, City Cement Inspector of Columbus, Ohio, in whose hands, at the suggestion of Professor Orton, Director of the Ohio Survey, the testing of the materials was placed, will be given in full in another report now in course of preparation. His report gives analyses of the materials and physical tests of cement actually made from them, and concludes as follows:

"1. The chemical analysis shows that the raw materials are susceptible of proper combination for Portland cement manufacture.

"2. The cement produced by the combination of these materials gave satisfactory tests in every respect."

Prof. A. F. Foerste has prepared a report which includes an extended discussion of the economic values of the clays and limestones of the Silurian, Devonian, and Irvine formations. It will be issued as a separate bulletin because of the necessity for detailed descriptions and classifications of the formations involved. This bulletin is in the hands of the printer.

BUILDING STONES.

The study of the building stones of the State was placed in the competent hands of Mr. W. U. Grider, who spent a portion of the season of 1905 in gathering data and making collections, in the course of which work he visited Bullitt, Hart, Warren, Washington, Todd, Logan, Christian, Trigg, Lyon, Simpson, Marion, Nelson, and other counties. Unfortunately and unexpectedly, however, he found it necessary to withdraw from the Survey within three months after taking up the work. At the time, it was hoped he would be able to return before the end of the season, but circumstances have prevented his doing so. Mr. Grider has presented a partial report in which is contained a large amount of valuable and practical information, including descriptions of beds suitable for quarrying for various purposes, methods of quarrying at various points, analyses and physical tests of a number of stones, photographs of exposures, etc. He also has data relating to many other counties than those named, needing but little more field work to enable him to complete descriptions of the stone resources of those counties. It is to be hoped that the work may yet be carried to completion by him.

THE COALFIELDS.

The Big Sandy Valley.—A report by Prof. A. R. Crandall on the coals of the Big Sandy Valley, south of Louisa and Warfield, including the headwaters of the North Fork of the Kentucky river, is in the hands of the printer. It contains many maps and graphic sections. The report covers about 2,000 square miles, and includes Johnson, Martin, Floyd, and Pike counties, part of Letcher, part of Knott, and the larger part of Lawrence county. The presentation of such a report at this

time was rendered possible by the fact that Prof. Crandall had spent several years at work in the Eastern Field as a member of the old Survey. He completed his study of the region during the season of 1904 and the early part of 1905. Many applications for this report, from prospective investors and from parties contemplating the acquirement of mining leases (in which way a large part of the actual development of the Eastern Field must necessarily be done), have already been received. A report on the northern part of the Valley was published some years ago.

Coals of the Licking Valley.—During the season of 1905 Prof. Crandall began work on the coals of the Licking Valley and headwaters of the Red river, including Morgan, Magoffin, Menefee, and Wolfe counties, but he could not complete all the field work necessary for a report before the end of the season. He has the report in course of preparation, but some weeks more of field work will be required before it can be completed.

The Pine Montain-Cumberland Region.—During the summer of 1904, Messrs. Shaw and Montgomery were at work determining the precise levels and locations of the various coal-beds north of Pine Mountain in Bell and Knox counties, preparatory for the completion of a report on that region by Mr. G. M. Sullivan, the expectation being that Mr. Sullivan would be in position to take up the work early in 1905. In this the Survey has been disappointed. Since Mr. Sullivan had nearly completed all the field work necessary for a report on a large area in that district, extending into Clay and Leslie counties, and including all of Bell and Knox counties, and a part of Harlan, it was desirable from every point of view that the work on the coals there should be placed in his hands. It is to be hoped that this may yet be done.

Mining Thin Seams.—A report on the methods that have proven successful in mining thin coal seams in the Southeastern Coalfield, by Mr. R. H. Barclay, is ready for the printer. It is deemed appropriate for this report to be printed in the report of the Inspector of Mines for 1905, and without objection this will be done.

The Western Coalfield.—Work on the higher and lower coals of the Western Coalfield, which was begun in 1904, was continued during the season of 1905. This work is in the hands of the Director, assisted by Mr. S. A. Denny. We are discovering facts in regard to the upper coals of this difficult field, as revealed in the work in Ohio, Muhlenberg, McLean, Hopkins, Webster and Union counties, together with data from Henderson county, which will necessitate a sharp revision of opinions hitherto held in regard to the distribution and order of the coal-beds.

Among the most important facts definitely determined is the occurrence of a large number of coal-beds above the one hitherto accepted as the highest workable seam ("No. 12"), including at least three, possibly more, beds that are workable in places. These upper coals, which in some instances hitherto have been mistaken for No. 11, or No. 12, or No. 9, as the case was, are variable in quality and thickness. Quite apart from their local values, however, the recognition and tracing of these coals as distinct beds, occupying horizons high above the position of No. 12 in the scale, is of much importance in the development of various parts of the field. A report is in preparation, presenting the results of the work so far, but the field is quite difficult, much complicated by faults and unconformities, and it will not be possible to issue a satisfactory report on the coals without having another season of field work.

The Rough Creek Anticline.—Prof. W. F. Pate began work along the Rough Creek anticline, in Western Kentucky, during the summer of 1905. This anticline is part of a very important disturbance which apparently extends quite across the State, in an approximately east and west direction, from Shawneetown, Ill., to near Warfield, Martin county. It is important to know what relation this uplift bears to the coals of the Western Field, especially in Ohio, McLean, Webster, Henderson, and Union counties, and its study is also of value in the prospecting for petroleum and gas. The results of the season's work are of much economic interest, but it will require at least another full season of field work, possibly more, to gain a satisfactory understanding of the disturbance.

In addition to his work on the anticline, Prof. Pate examined

the coals in the region adjacent to the Fordsville branch of the Louisville, Henderson & St. Louis railroad, and obtained data for the revision of the Meade county report, referred to beyond.

OLD REPORTS.

At the time the Survey was suspended, in 1892, there were four reports ready for the printer, namely, one on Breckenridge county, by J. B. Hoeing; one on Meade county and one on Livingston county, by R. H. Loughridge, and one on Warren county, by M. H. Crump. The Breckenridge and Meade reports have been revised and brought to date, and will be printed, as is provided for by the present Survey law. Col. Crump is expected to revise and bring to date his report on Warren county. As stated elsewhere, Mr. Fohs is now preparing what is in effect a new report based on Dr. Loughridge's Livingston report.

CLASSIFICATION OF FORMATIONS.

Prof. A. F. Foerste has in hand the preparation of a report on the Cincinnatian (formerly known in Kentucky reports as the Hudson) series. It is expected that it will be ready for the printer at an early date. It will include twenty-one plates of typical fossils, which will render it of exceeding value to those who find it necessary to identify the rock beds in the areas covered by this formation. It should prove especially useful to persons engaged in boring for gas (seeking the gas horizons in the deep-lying rocks) where the Cincinnatian forms the surface, and it should prove useful in the schools of the State.

Prof. J. M. Nickles, to whom was confided the work of discriminating certain of the divisions of the Cincinnatian, concerning which there was much uncertainty, has prepared his report, which includes three plates of fossils, and it is in the hands of the printer.

Prof. A. M. Miller continued his study of the Mohawkian during the past summer, and has prepared a revision of the table given in his published report on the lead and zinc-bearing rocks of Central Kentucky. His table, including classifications of the Cincinnatian by Foerste and Nickles, together with remarks thereon, will appear in another report.

This work of classification has been taken up because it is absolutely necessary for an adequate study of the economic

values (including petroleum and gas) of the Lower Silurian rocks that we shall have a proper classification of the latter. The practical value of a correct classification of the rocks is illustrated in the bulletin on oil and gas, where the Ragland and Estill oil sands are identified as Corniferous rather than Clinton, to which they have usually been assigned. As a consequence of this, a larger region becomes of interest as regards the possible finding of petroleum than if the Clinton were the important oil rock, since the Corniferous has an evener distribution than the Clinton. It also affords a more intelligent basis from which to work in the western counties. Another illustration of the practical value of such work is this: In the progress of his work on classification during the past season, Prof. Miller discovered the exact representatives of the rock phosphate beds of Mt. Pleasant, Tenn., some examples running as high as 72 per cent. phosphate, and having definitely differentiated them, he was able to trace them over considerable areas.

A bulletin giving a revised classification of the formations of the State, together with a new edition of the State geological map, is projected. Work upon both bulletin and map is in progress.

ROCK PHOSPHATE.

As indicated in the preceding section, noteworthy deposits of rock phosphate were found within the Lower Silurian (Ordovician) area during the past season, and the possibility of establishing a commercial enterprise upon them seems worth considering. While it may be that it will not prove practicable to undertake the mining of high-grade phosphate for disposal to fertilizer works, it does seem feasible to establish a custom grinding mill for the production of "agricultural lime," for which this phosphate rock is eminently suitable since it may be spread where needed without further preparation. Even in the Bluegrass there are now many acres of land that need lime. These phosphate layers, even those lowest in phosphoric acid, gathered and ground, would yield high values. As indicated above, they may be used in the natural state and meet all requirements. The rock, in the form of thin, rather porous-looking, yellowish brown plates, where weathered, comes in at the

top of the Lexington Limestone ("Trenton"). In a memorandum on the subject, Prof. Miller says: "There is hardly a locality where the top of this formation has been exposed in upland situations as the result of slow denudation of the overlying beds, where thin plates of this phosphate can not be found, and recently samples were collected from a locality in Woodford county that indicated a deposit there of phosphate of a very promising character. They ran as high as 33 per cent. phosphoric acid (72 per cent. calcium phosphate). The samples first collected consisted of plates of leached limestone from half an inch to an inch and a half in thickness, and weighing from one to three pounds. These lay scattered very thickly over the surface of a roadside slope, and on digging down were found disseminated through the soil nearly to the bed-rock—here from 1 to 2 feet below the surface. In the light of all that is known at present, the most favorable district for prospecting is in that comparatively level and very fertile belt of country extending northward from Versailles to Midway, and again beginning on the other side of South Elkhorn, in Scott, and extending in the same direction to where the land begins to fall off to the level of North Elkhorn. Fayette county also offers a promising field. The soil at the phosphate horizon is a very deep red, and is characterized by the presence of a 'honey-comb' coral of the genus Columnaria." Samples of the rock may be seen in the State Geological Museum, Lexington.

CO-OPERATION IN TOPOGRAPHY.

The State Survey has issued many maps which are quite good enough to use in showing the location of mineral outcrops, mines, quarries, etc., but they are not of the sort necessary to use in laying down details of geology, in tracing the extension of coal beds and other deposits, in determining in advance of actual field examination the probable routes for transportation lines, etc. For such purposes maps must show the surface of the country by means of contour lines. Such character of mapping is very costly, and on that account it was deemed advisable to seek co-operation with the U. S. Geological Survey, the expense of the field work to be equally divided between the State and Federal organizations. In the appropriation section

of the Survey law enacted by the last Legislature, therefore, the sum of $5,000 out of the total annual appropriation of $15,000 was allotted for co-operation in topography with the U. S. Geological Survey. An agreement with the Director of the U. S. Geological Survey was entered into in March, 1904. In the agreement it was provided that the Federal Survey should expend an amount equal to that allotted by the State Survey; that the work should be carried on under the supervision of the Director of the U. S. Geological Survey, subject to proper inspection and criticism by the Director of the State Survey; that the cost of publication should be borne by the U. S. Survey; and that when desired, the State Survey should be furnished with transfers, at cost of printing, from the copper plates of the topographic sheets, for use in printing editions of said maps. In designating the portions of the State in which work should be done, it was thought proper that those parts in which the U. S. Survey had done no work should first receive attention. That Survey had covered the Eastern Coalfield in preceding years; hence, although it was known to be desirable that much of the ground be resurveyed, it was thought just that it should await until some of the wholly unsurveyed regions should be gone over, and until a more nearly adequate appropriation should be made. For the season of 1904, the areas selected were the Sutherland quadrangle south of Owensboro, the Sebree and Morganfield sheets, in Western Kentucky, and the thirty-minute quadrangle in which Frankfort is situated. For the season of 1905 the Louisville quadrangle was added, together with certain adjacent areas. The Louisville quadrangle was selected because of the great necessity there was for an accurate, contoured map to use in working out sewerage plans for that populous city. The following work has been accomplished, as set forth in statements for each year received from the Director of the U. S. Geological Survey:

Results for 1904.—"During the season a complete and accurate map, on a scale of 1.62,500, with a contour interval of 20 feet, of 517 square miles of area of the State was surveyed. The results will be published on parts of the following four atlas sheets, namely, Sebree, Sutherland, Frankfort, and Georgetown, the first two being completed in the field. These sheets cover portions of the counties of Anderson, Daviess, Fayette, Frank-

lin, Henderson, McLean, Ohio, Scott, Shelby, Union, Webster and Woodford. Some additions were also made to the Calhoun, Newburg (Ky.-Ind.), and Owensboro (Ky.-Ind.), and Harrodsburg completed sheets.

"In all, 519 square miles of sketching was done, 1,214 miles of spirit levels were run, with thirty-three permanent bench marks, and 10,116 elevations. There were also run 2,295 miles of road traverse.

"During the season 426 miles of traverse for primary control was extended over portions of the counties of Anderson, Daviess, Fayette, Franklin, Grant, Henry, Jefferson, Ohio, Owen, Scott, Union, Webster, and Woodford."

Results for 1905.—"From the expenditure of the funds providing for this co-operation a complete and accurate map has been made on the scale of 1.62,500, with a contour interval of 20 feet, of 235 square miles of the area of the State, represented on the Louisville quadrangle, in Jefferson, Spencer and Bullitt counties, and of 7 square miles represented on the New Haven (Ill.-Ind.-Ky.) quadrangle, in Union county. During the progress of this work the city of Louisville was mapped on the field scale of 1.22,500 for publication on the scale of 2,000 feet to 1 inch, and will be reduced to form parts of the Louisville sheet, and of the uncompleted Prospect, Riverview and New Albany sheets. The area of the city map, including the suburbs, covers 37 square miles of the area of the completed Louisville sheet, and is included in the above statement of its area.

"During this work 533 miles of spirit levels were run, in the course of which 2,958 elevations and twelve permanent bench marks were established. There were run 794 linear miles of road traverse, every bend and every house being accurately located.

"In addition to the above completed sheets there were finally mapped 188 square miles on the Georgetown sheet, in Fayette, Franklin, Scott and Woodford counties, and 117 square miles of the area of Prospect (Ky.-Ind.) quadrangle, in Jefferson and Oldham counties. Considerable secondary control was procured on the Morganfield quadrangle, in Crittenden, Union, and Webster counties, and on Riverview quadrangle (Ky.-Ind.), in Jefferson and Bullitt counties. On this unfinished work 756 miles of spirit levels were run, in the course of which 3,970 elevations

and eight permanent bench marks were established; there were also run 1,834 linear miles of road traverse.

"One party extended primary traverse over the counties of Anderson, Bullitt, Jefferson, Oldham, Shelby, and Spencer, resulting in the occupation of 999 stations, and the running of 86 miles of traverse. This primary traverse is something more and in addition to what had been anticipated and planned at the beginning of the season. It was found that the triangulation about Louisville was not on the United States Standard Geodetic datum, but was a result of some special triangulation extended some years ago in the neighborhood of the city. In order that the resulting maps might conform with the others which we are making in the State, it was deemed desirable to connect this primary control with that in the neighborhood of Frankfort and Georgetown, so that it might be reduced to the standard datum, and be sure that there would be no discrepancies in the work coming from both directions. For that reason a line of primary control was run between these two areas. Inspection of the work done in the previous year on the Calhoun sheet developed the fact that the sketching of the topographer who had mapped that sheet was not up to the standard at which we are aiming, and it was deemed desirable not to publish the results until the field work be gone over and the sketching corrected in such places as it was found to be in error. Accordingly, the final publication of the Calhoun sheet is held up pending such revision as may prove necessary."

It will be observed that within the two years 1,064 square miles have been accurately mapped, while a large amount of work toward completing other large areas was also done. Mr. H. M. Wilson, Geographer of the U. S. Geological Survey, has had general charge of the work.

HYDROGRAPHY.

One of the most important duties with which the Survey is charged is the study of our water supply, both above and below ground. We need to know not only the water horizons and the character of the ground waters, but also the varying quantity and quality of the surface streams; the latter we must know in order that as population increases and with it an increasing pollution of the streams, we may act intelligently in adopting

methods for rendering the water supply suitable for domestic use. In such study there are many elements to be considered. A tentative co-operative arrangement, dependent upon the maintenance of the State Survey, has been effected with the Hydrographic Branch of the U. S. Geological Survey, by which this important work may be carried on next season.

TIMBER RESOURCES.

The Survey law contemplates the study of the timber resources of the State. Realizing the advantage there would be in having this done by trained men from the Forestry Division of the U. S. Department of Agriculture, the question of co-operation was presented to the Chief Forester. A cordial response was received, but the amount ($1,000) deemed proper for the Survey to allot for the season's work was more than the funds at the command of the Survey would permit; hence it was necessary to defer the work. With the continuation of the Survey, provided with an adequate appropriation, co-operation with the Department of Agriculture in the study of our timbers will again be sought.

CANNELS AND LOWER COALS OF THE EASTERN FIELD.

A report on the cannels of the Eastern Field is projected. Also one on the coals of the Conglomerate Measures. An adequate study of these subjects will yield valuable returns. Assurances have been received that should the Survey succeed in finding good areas of coal fit for producing iron-making coke in the western outcrop of the Conglomerate series, an iron furnace will be erected to utilize ores in the region to which the coke would be tributary.

SOIL SURVEY.

An arrangement has been effected with Prof. M. A. Scovell, Director of the State College Agricultural Experiment Station, for co-operation in the study and mapping of the soils of the State. This insures that the work will be carried along accurate and practical lines, such as will prove of real service to the agriculture of the State.

UPPER CUMBERLAND AND KENTUCKY RIVER VALLEYS.

It is believed that, under favorable conditions, another season will give us a report on the Kentucky River Valley similar to that which is now ready on the Big Sandy region. Otherwise, more time will be required. The Upper Cumberland is a big field, and important because of the great thickness of coal-bearing rocks there. It is believed that with well-organized prospecting, and since much work has already been done there, a report on that region can be made after two more seasons of work.

PROSPECTING CORPS.

The Survey has always done a great deal of pioneer work in the coalfields, making hundreds of openings in the Eastern Field especially, since it long ago became impracticable to rely on residents of a region to make openings at their own expense. This is costly work and has been a severe tax on the Survey funds. To accomplish the same results more rapidly and at less relative expense, it is contemplated to acquire a small drilling outfit and organize a drilling corps to work not only in both coalfields, but to test the extension of clay deposits, and so on.

CHARTING THE DIPS OF THE ROCKS.

The proposed charting of the dips of the rocks throughout the State has been mentioned on a preceding page. The mapping of the anticlines and synclines is not only of prime importance to oil and gas development, but it will prove of exceeding value to the coal mining interests. It will enable the prospective operator to determine how to best develop such properties as may be under consideration; he will know how the mines must be laid out to obtain best results with respect to drainage and haulage, also whether in the progress of mining in a certain direction material changes of dip may be expected which would affect the manner of mining, and so on. Mining engineers, especially those who have had experience in the more eastern regions of the Appalachian field, will recognize this as one of the most practical and useful lines of work the Survey can undertake.

FIRECLAYS AND BALL CLAYS.

Kentucky affords the highest quality of flint fireclays known in this country. Practically all known areas of the famous Carter clay have been taken up by the firebrick companies. It is proposed to continue the search for such clays along the western edge of the Eastern Coalfield. There is an eager demand for first-class ball clays. It is proposed to make especial search for additional deposits of these.

MISCELLANEOUS MAPS.

A map of the Eastern Coalfield, based on surveys made by the State and Federal Surveys and on data obtained from other authentic sources, on a scale of three miles to the inch, but which in printing will be reduced to four miles to the inch, on which to indicate the outcrop lines of the more important coals of the field, has been prepared.

A similar map for the Western Coalfield was projected, but could not be undertaken because of lack of funds.

A revision of the State geological map is in progress and will be completed in time for publication of the map about June, 1906, should the necessary appropriation for the Survey be made.

In addition, a considerable number of maps is projected, showing the distribution of the various economic resources of the State.

LIST OF REPORTS.

Reports Printed, in the Printer's Hands, or in Preparation.

1. Oil and Gas Sands of Kentucky; 3 maps, 10 plates. By J. B. Hoeing. *Printed.*

2. Lead and Zinc Bearing Rocks of Central Kentucky; map and 12 plates. By A. M. Miller. *Printed.*

3. Chemical Report of Clays, Coals, Ores, etc., by Dr. Robert Peter, late Chemist of the Survey; 236 analyses. *In hands of the printer.*

4. Coals of the Big Sandy Valley, covering 2,000 square miles, including Lawrence, Johnson, Martin, Floyd and Pike counties, and parts of Knott and Letcher counties; many maps and illustrations. By A. R. Crandall. *In hands of the printer.*

5. The Upper Ordovician Rocks of Kentucky and their Bryozoa; 2 plates of fossils. By John M. Nickles. *In hands of printer.*

6. Clays in several parts of Kentucky, by J. H. Gardner and A. F. Foerste. *In hands of printer.*

7. Silurian, Devonian, and Irvine Formations of East-Central Kentucky, with an account of their clays and limestones; 18 plates, including map. By A. F. Foerste. *In hands of printer.*

8. Mining Thin Coal Seams of the Southeastern Coal Field; many diagrams and illustrations. By R. H. Barclay. *Ready for printer.*

9. The Upper and Lower Coals of the Western Coalfield; maps and many sections. By C. J. Norwood and S. A. Denny. *In preparation.*

10. Reports on Breckenridge and Meade Counties; Originally prepared in 1891, but revised and brought to date; maps and many plates. By J. B. Hoeing and R. H. Loughridge. *Ready for printer.*

11. The Mineral Veins of Central Kentucky: Lead and Zinc, Barite, Fluorite, and Calcite; maps and plates. By C. J. Norwood and J. E. Wright. *In preparation.*

12. The Coking Coals of Kentucky and the Economic Values of the Cokes Made Therefrom. By C. J. Norwood. *In preparation.*

13. Livingston County: Its Mineral Veins and Other Resources. By F. J. Fohs. *In preparation.*

14. The Iron Ores of Kentucky. By C. J. Norwood. *In preparation.*

15. The Cincinnatian Rocks of Kentucky; 21 plates of fossils. By A. F. Foerste. *In preparation.*

16. The Lead, Zinc and Spar Deposits of Western Kentucky; maps and illustrations. By F. J. Fohs. *In preparation.*

RECOMMENDATIONS

As to Increasing the Efficiency of the Survey.

For so long has Kentucky been regarded, not only abroad, but at home, as primarily an agricultural State; for so long have our activities been almost wholly along agricultural lines, that it seems no less difficult to persuade our own people that we have a great mineral State as well as a wonderfully fine agricultural one, than it is to convince the investing capital that is flowing past us that such is the case. And yet, that this is so is perhaps not strange; the association of mineral deposits with fertile lands, such as we have, is not common, but quite the reverse, and for years we have been at the disadvantage of having no bureau to work out and offer proof as to the value of our varied mineral resources, while competing States (so to call them) have steadily maintained their Surveys.

According to the closest computations that have been made, the area of the State is about 41,283 square miles. Of that expanse, about 15,680 square miles are covered by coal-bearing formations; a region of about 2,000 square miles in the west is rich in lead, zinc, and fluorspar deposits; in the central part, lead, zinc, barite, calcite, and fluorspar veins, that will unquestionably prove of exceeding value, are found over a region about 4,000 square miles in extent; over the whole of the "Purchase Region," an area of about 2,340 square miles, splendid clays abound, together with excellent sands, valuable silicious earths and other minerals; adjacent to the eastern and southern margins of the Western Coalfield is an area of perhaps 1,000 square miles, in which are to be found most excellent kaolins and plastic clays; in addition to which are the great areas of fine clay and cement-making material on the rim of the "Bluegrass," and on the margin of the Eastern Coalfield, the hundreds of square miles underlaid by iron ores, asphalt rock, building stones of the highest order, oil and gas, and so on. Indeed, it is doubtless within bounds to say that more than two-thirds of the total area of the State, including even the most fertile region in it, is mineral-bearing. That Kentucky is primarily a farming State is because we have made it so; it is because we have em-

phasized the agricultural side, and have either overlooked or neglected the mineral side. It ought to be a great industrial State, and at this time, while there is need for more people to till the soil, there is greater need for an immigration of manufacturing industries to provide more and better markets for the products of the farm, and to provide occupations for our young men.

Industrial capital will come to Kentucky when we are prepared to show in an efficacious way what advantages the State has to offer in raw material, well placed geographically. This can not be accomplished by means of "private" reports, however excellent they may be. There is but one potent way, and that is to maintain an efficient Geological Survey. Under present conditions, $10,000 per annum (that being the amount hitherto granted for the individual work of the State organization) is too little for the Survey to carry on its work most efficiently. Had the Survey not been so abruptly suspended some years ago, even less than $10,000 per annum would have served to complete a careful study of the economic geology within a few years; but as matters stand, much that was partially covered years ago, but not reported on, must now all be gone over again. There are regions, in the south-central part of the State especially, about which we know practically nothing. Years ago the search for the various economic materials, locating them and determining their extent, should have been completed, and we ought now to be in position to devote our attention chiefly to the technical questions relating to them. As matters are, the Survey has been unable to go far into technical questions, and yet they must be dealt with if we are to meet present-day requirements. I recommend that the amount for the individual work of the State organization be increased.

As I have already indicated, in order that our geological formations, with their economic values, may be laid down in accurate detail on maps, we must have a higher order of maps than the State can well afford to undertake alone. We must look to the U. S. Geological Survey for co-operation in topography, the policy of that Survey being to expend in such work an amount equal to that allotted by the State. With the allotment hitherto made, a large area has been covered, but with $5,000 per annum we can not proceed as rapidly in our mapping as the ne-

cessities of the State require. It is doubtful whether there is a State in the Union that stands in greater need of good maps than does Kentucky. As an illustration of this, I present a list of counties showing variations in areas as reported in some of our official documents compared with the areas as determined from the most accurate maps that have been made of the counties. It would be wise to increase the amount allowed for co-operative topography.

COMPARATIVE LIST OF COUNTY AREAS.

County.	As given in official documents issued at different times. Square miles.		As computed from maps of the counties. Square miles.
	1	2	
Ballard	250	240	235.2
Bath	270	253	272.5
Bell	350	284	393.625
Boyd	130	120	171.5
Boyle	180	171	187
Breathitt	450	434	485.5
Breckenridge	520	472	579
Butler	452	397	422.125
Caldwell	315	295	345
Calloway	434	376	403
Carlisle	190	174	191
Carter	544	368	411.5
Clark	260	245	255.5
Clay	580	385	459
Clinton	220	152	224
Crittenden	340	335	376.25
Elliott	270	220	261
Estill	250	193	255
Fleming	340	332	333
Floyd	410	403	409
Fulton	190	175	178.6
Garrard	225	210	238.5
Graves	550	488	540
Greenup	352	283	371
Harlan	410	667	472.125
Hart	410	362	427.25
Henry	272	278	306.25
Hickman	240	227	229.5
Jackson	305	299	363.75
Johnson	300	284	271.25
Knott	365	370	347.625
Knox	350	307	357.5

County.	As given in official documents issued at different times. Square miles.		As computed from maps of the counties. Square miles.
	1	2	
Laurel	450	352	466.5
Lee	228	229	203.25
Leslie	420	383	341
Letcher	310	445	358
Lincoln	328	291	325.75
Livingston	360	291	370.375
Lyon	275	216	243
Madison	385	409	378
Magoffin	300	312	299.25
Marion	336	304	344
Mason	225	232	220.625
McCracken	250	249	237.3
Meade	332	308	323.75
Mercer	250	240	263.5
Montgomery	200	181	205
Nelson	380	400	411.375
Ohio	610	538	571.75
Oldham	170	182	184.75
Owsley	176	178	242
Perry	448	371	351.5
Powell	144	132	176.5
Rockcastle	280	280	305
Shelby	405	375	397
Spencer	200	180	189.5
Trigg	425	348	448
Warren	530	512	563
Washington	300	278	315
Whitley	580	631	600.8
Wayne	590	493	570
Wolfe	190	244	243.375

DISBURSEMENTS OF THE APPROPRIATION.

Following is a statement of the disbursements of the appropriation from April 1, 1904, to December 1, 1905. The items are arranged according to the headings under which they are entered in the Survey account book:

ON ACCOUNT OF GEOLOGY.

1904.		Salary.	Expenses.	Total.
April 14.	J. B. Hoeing.....	$ 26 00	$16 30	$ 42 30
April 26.	J. E. Wright.....	48 00	37 26	85 26
April 30.	C. R. Gilmore.....	.....	3 48	3 48
April 30.	J. H. Gardner.....	.....	6 79	6 79
April 30.	W. C. Payne.....	.....	1 50	1 50
April 30.	S. A. Denny.....	.....	4 52	4 52
April 30.	A. M. Miller.....	.....	7 93	7 93
May 25.	J. B. Hoeing.....	100 00	18 75	118 75
May 26.	J. E. Wright.....	60 00	42 18	102 18
May 16.	S. A. Denny.....	.....	1 42	1 42
May 16.	C. R. Gilmore.....	.....	3 40	3 40
June 30.	J. B. Hoeing.....	104 00	31 51	135 51
June 30.	G. V. Triplett, Jr.....	50 00	.....	50 00
June 30.	John Goff....(37 days, April 16 to June 1).....	74 00	.....	74 00
July 2.	A. M. Miller.....	44 00	16 25	60 25
July 13.	A. M. Miller.....	32 00	7 25	39 25
July 30.	A. M. Miller.....	44 00	19 72	63 72
July 30.	J. B. Hoeing.....	104 00	38 07	142 07
July 30.	S. A. Denny.....	30 00	22 30	52 30
July 30.	R. H. Barclay.....	45 00	34 67	79 67
July 30.	J. H. Gardner.....	30 00	11 07	41 07
July 30.	M. Fischer	60 00	55 57	115 57
July 30.	J. E. Wright.....	36 00	29 20	65 20
July 30.	A. M. Miller, balance of salary, May, June and July..	30 00	.....	30 00
Aug. 19.	M. Fischer.....	.....	28 21	28 21
Aug. 20.	A. F. Foerste.....	.....	58 77	58 77
Aug. 26.	A. M. Miller.....	50 00	32 14	82 14
Aug. 27.	J. E. Wright.....	44 00	38 96	82 96
Aug. 30.	J. B. Hoeing.....	96 00	33 95	129 95
Aug. 30.	R. H. Barclay.....	45 00	52 65	97 65
Aug. 30.	S. A. Denny.....	30 00	26 60	56 60
Aug. 30.	M. Fischer	60 00	37 46	97 46
Aug. 30.	J. H. Gardner.....	30 00	24 10	54 10
Aug. 30.	W. F. Pate (for July).....	15 00	6 15	21 15

1904.		Salary.	Expenses.	Total.
Aug. 30.	W. F. Pate (for August)....	13 00	15 95	28 95
Aug. 31.	A. F. Foerste (May, July and August).....	164 00	21 33	185 33
Sept. 30.	Transylvania Co., films, 90 cents; envelopes, 50 cents.	.....	.....	1 40
Sept. 30.	R. H. Barclay.....	45 00	.....	45 00
Sept. 30.	S. A. Denny.....	30 00	44 02	74 02
Sept. 30.	J. H. Gardner.....	26 60	31 53	58 13
Sept. 30.	A. F. Foerste.....	68 00	44 01	112 01
Sept. 30.	J. B. Hoeing.....	104 00	30 94	134 94
Sept. 30.	C. L. Jones (collecting well records)	.....	21 69	21 69
Sept. 30.	A. M. Miller.....	50 00	3 00	53 00
Sept. 30.	J. E. Wright.....	88 00	64 85	152 85
Oct. 31.	M. Fischer	18 00	40 20	58 20
Oct. 31.	R. H. Barclay.....	45 00	.....	45 00
Oct. 31.	A. R. Crandall.....	187 50	63 65	251 15
Oct. 31.	S. A. Denny.....	30 00	14 85	44 85
Oct. 31.	J. H. Gardner.....	40 00	33 53	73 53
Oct. 31.	J. B. Hoeing.....	104 00	5 60	109 60
Oct. 31.	A. M. Miller.....	50 00	3 40	53 40
Oct. 31.	G. V. Triplett, Jr.....	50 00	1 95	51 95
Oct. 31.	J. E. Wright.....	40 00	25 11	65 11
Oct. 31.	M. G. Clay, making blue prints	.....	.....	3 76
Nov. 30.	R. H. Barclay.....	45 00	0 25	45 25
Nov. 30.	S. A. Denny.....	40 00	39 18	79 18
Nov. 30.	J. H. Gardner.....	16 00	18 23	34 23
Nov. 30.	J. B. Hoeing.....	104 00	17 97	121 97
Nov. 30.	A. M. Miller.....	50 00	12 77	62 77
Nov. 30.	G. V. Triplett, Jr.....	50 00	1 95	51 95
Nov. 30.	J. E. Wright.....	24 00	19 64	43 64
Nov. 30	Jas. Mullen, printing photos	.....	.....	3 90
Nov. 30.	Transylvania Co., 1 dozen photo plates.....	.....	.....	50
Dec. 31.	R. H. Barclay.....	45 00	0 25	45 25
Dec. 31.	S. A. Denny.....	40 00	0 25	40 25
Dec. 31.	J. H. Gardner.....	40 00	18 31	58 31
Dec. 31.	J. B. Hoeing.....	88 00	5 70	93 70
Dec. 31.	A. M. Miller.....	50 00	12 64	62 64
Dec. 31.	G. V. Triplett, Jr.....	50 00	.....	50 00
Dec. 31.	J. E. Wright.....	28 00	5 28	33 28
Dec. 31.	A. F. Foerste.....	128 00	14 95	142 95
Dec. 31.	A. G. Spillman, collecting coals	.....	.....	100 00
Dec. 31.	Transylvania Co., 1 dozen photo plates.....	.....	.....	35

1905.		Salary.	Expenses.	Total.
Jan. 31.	F. J. Fohs	$16 00	.....	$ 16 00
Jan. 31.	G. V. Triplett, Jr	60 00	$1 70	61 70
Jan. 31.	J. H. Gardner	50 00	25	50 25
Jan. 31.	R. H. Barclay	45 00	25	45 25
Jan. 31.	J. B. Hoeing	104 00	.....	104 00
Feb. 1.	A. M. Miller	50 00	.....	50 00
Feb. 1.	W. F. Pate	16 00	1 81	17 81
Feb. 2.	S. A. Denny	40 00	.....	40 00
Feb. 20.	Shaffer Art Co., photo prints (December)	.....	.....	80
Feb. 28.	G. V. Triplett, Jr	60 00	25	60 25
Feb. 28.	S. A. Denny	40 00	.....	40 00
Mar. 1.	W. U. Grider	107 00	10 30	117 30
Mar. 1.	J. B. Hoeing	96 00	11 50	107 50
Mar. 1.	A. M. Miller	50 00	.....	50 00
Mar. 1.	J. H. Gardner	50 00	25	50 25
Mar. 1.	R. H. Barclay	45 00	25	45 25
Mar. 7.	Jas. M. Byrnes, 250 circulars (January)	.....	.....	2 50
Mar. 8.	J. E. Wright (January)	12 00	4 48	16 48
Mar. 9.	A. R. Crandall	100 00	.....	100 00
Mar. 10.	A. F. Foerste (Jan., Feb.)	120 00	14 01	134 01
Mar. 30.	G. V. Triplett, Jr	60 00	25	60 25
Mar. 30.	R. H. Barclay	45 00	25	45 25
Mar. 31.	A. M. Miller	50 00	.....	50 00
April 2.	A. F. Foerste	87 97	24 58	112 55
April 1.	F. J. Fohs	60 00	24 25	84 25
April 1.	W. U. Grider	125 00	55 45	180 45
April 1.	J. B. Hoeing	72 00	6 65	78 65
April 1.	A. R. Crandall	50 00	.....	50 00
April 6.	M. G. Clay, making blue prints	.....	.....	10 45
April 1.	J. H. Gardner	50 00	17 01	67 01
April 1.	S. A. Denny	40 00	5 04	45 04
April 29.	A. M. Miller	50 00	.....	50 00
April 29.	S. A. Denny	50 00	12 68	62 68
April 29.	Gross vials, April 15, from Director's account			
April 29.	J. H. Gardner	50 00	34 75	84 75
April 29.	J. E. Wright	62 50	33 87	96 37
April 29.	J. B. Hoeing	125 00	13 10	138 10
April 29.	F. J. Fohs	112 00	66 30	178 30
April 29.	M. G. Clay, blue prints	.....	.....	2 05
May 5.	E. M. Denham, drawing maps	.....	.....	12 20

1905.		Salary.	Expenses.	Total.
May 8.	W. F. Pate (March, April and May).....	24 00	6 56	30 56
May 8.	G. V. Triplett, Jr.....	42 00	50	42 50
May 8.	W. U. Grider.....	62 50	32 97	95 47
May 19.	E. M. Denham, drawing maps	.....	.....	4 00
May 19.	A. F. Foerste (April).....	58 33	.....	58 33
May 31.	S. A. Denny.....	50 00	.....	50 00
May 31.	R. H. Barclay (April, May).	90 00	.....	90 00
May 31.	J. E. Wright.....	125 00	54 77	179 77
May 31.	J. H. Gardner.....	50 00	60 58	110 58
May 31.	M. G. Clay, 1 blue print....	.....	.....	35
May 31.	A. R. Crandall (April, May)	112 00	.....	112 00
May 31.	F. J. Fohs.....	120 00	68 67	188 67
May 31.	A. M. Miller.....	50 00	2 30	52 30
June 13.	A. F. Foerste (May).....	76 61	13 01	89 62
June 8.	L. M. Prince, 26 blue prints.	.....	.....	7 85
June 24.	O. R. Kroell, drafting.....	.....	.....	36 00
June 28.	L. M. Prince, blue prints...	.....	.....	1 20
June 28.	J. M. Nickles.....	.....	57 72	57 72
June 28.	A. M. Miller.....	50 00	32 74	82 74
June 28.	J. H. Gardner.....	50 00	48 15	98 15
June 28.	A. F. Foerste.....	95 83	38 79	134 62
June 28.	J. E. Wright.....	104 16	46 48	150 64
July 3.	F. J. Fohs (June).....	120 00	66 55	186 55
July 3.	S. A. Denny (June).....	50 00	30 28	80 28
July 9.	J. B. Hoeing (May).....	125 00	42 72	167 72
July 9.	W. F. Pate (June).....	68 00	17 33	85 33
July 24.	J. M. Nickles.....	125 00	44 45	169 45
July 25.	L. M. Prince, blue prints...	.....	.....	1 50
Aug. 1.	A. M. Miller (July).....	50 00	37 50	87 50
Aug. 1.	J. H. Gardner (July).....	50 00	51 70	101 70
Aug. 1.	J. E. Wright (July).....	125 00	38 23	163 23
Aug. 3.	F. J. Fohs (July).....	120 00	50 05	170 05
Aug. 3.	S. A. Denny (July).....	50 00	41 60	91 60
Aug. 3.	W. F. Pate (July).....	68 00	20 65	88 65
Aug. 3.	A. R. Crandall.....	150 00	33 15	183 15
Aug. 17.	R. H. Barclay (June, July).	45 00	24 86	69 86
Aug. 9.	J. P. Brooks, compiling and drawing 2 large maps, June and July, and $1 drayage.	.....	.....	201 00
Aug. 31.	W. F. Pate.....	68 00	23 23	91 23
Aug. 31.	S. A. Denny.....	50 00	7 74	57 74
Sept. 1.	A. M. Miller.....	50 00	.....	50 00
Sept. 1.	F. J. Fohs.....	120 00	47 15	167 15
Sept. 1.	J. H. Gardner.....	50 00	67 63	117 63

1905.		Salaries.	Expenses.	Total.
Sept. 1.	J. E. Wright.....	125 00	.....	125 00
Sept. 6.	A. R. Crandall.....	150 00	55 70	205 70
Sept. 29.	J. H. Gardner.....	50 00	4 55	54 55
Oct. 3.	F. J. Fohs.....	120 00	1 30	121 30
Oct. 3.	A. M. Miller.....	50 00	.....	50 00
Oct. 31.	J. H. Gardner.....	$ 50 00	$1 55	$ 51 55
Nov. 3.	F. J. Fohs (Oct.).....	120 00	35	120 35
Nov. 28.	J. H. Gardner (Nov.).....	50 00	.....	50 00
Dec. 6.	F. J. Fohs (Nov.).....	120 00	18 35	138 35
Total April 1, 1904, to December 1, 1905.....				$12,168 51

SHORT STATEMENT OF FOREGOING.

Year.	Salaries.	Expenses.	Total.
1904	$3.338 10	$1,391 02	$4,729 12
1905	5,629 90	1,809 49	7,439 39
Totals	$8,968 00	$3,200 51	$12,168 51

ON ACCOUNT OF MISCELLANEOUS MAPPING, LEVELING AND DRAWING.

1904.		Salary.	Expenses.	Total.
April 25.	R. E. Mooreman (traveling)	.....	$ 4 75	$ 4 75
April 30.	R. E. Mooreman (drafting 6 days' salary).....	12 00	.....	12 00
May 10.	R. E. Mooreman (drafting, 8 days' salary)	16 00	.....	16 00
May 18.	O. R. Kroell (copying maps, 9 days)	.....	.....	9 00
June 30.	O. R. Kroell (drafting, 15½ days)	.....	.....	31 00
July 31.	G. V. Triplett, Jr. (special aid for July).....	50 00	32 00	82 00
July 31.	Hargis Hill, rodman.....	20 00	32 30	52 30
July 31.	J. G. Lewis, transitman....	45 00	24 71	69 71
July 31.	O. R. Kroell (drafting 5 days)	.....	.....	10 00
July 31.	O. R. Kroell, levelman, salary 24 days	19 35	31 65	51 00
July 31.	J. S. Shaw, transitman.....	25 00	23 58	48 58
July 31.	C. G. Montgomery, levelman	25 00	5 50	30 50

1904.		Salary.	Expenses.	Total.
July 31.	Items from Director's acct.:			
	July 21, broad hatchet ...	.....	.....	1 25
	July 22, L. Ayres, axman..	.....	.....	6 40
Aug. 31.	G. V. Triplett, Jr.....	50 00	50 40	100 40
Aug. 31.	Hargis Hill.....	20 00	25 05	45 05
Aug. 31.	J. G. Lewis.....	45 00	56 90	101 90
Aug. 31.	O. R. Kroell.....	25 00	12 70	37 70
Aug. 31.	J. S. Shaw.....	25 00	60 37	85 37
Aug. 31.	C. G. Montgomery.....	25 00	12 28	37 28
Sept. 30.	O. R. Kroell.....	4 00	.....	4 00
Sept. 30.	J. G. Lewis.....	45 00	26 01	71 01
Sept. 30.	Geo. D. Wright, rodman....	12 00	23 00	35 00
Oct. 31.	J. G. Lewis.....	45 00	28 36	73 36
Oct. 31.	B. M. Sims, rodman.....	20 00	15 19	35 19
Oct. 31.	B. M. Sims, September.....	20 00	18 09	38 09
Oct. 31.	J. S. Shaw.....	36 16	132 95	169 11
Nov. 30.	Transylvania Co., 1 dozen thumb tacks	.....	.....	10
Nov. 30.	J. G. Lewis.....	45 00	43 54	88 54
Nov. 30.	J. S. Shaw.....	38 34	39 11	77 45
Nov. 30.	G. V. Triplett, Jr.....	50 00	1 05	51 05
Dec. 24.	J. S. Shaw.....	40 00	25	40 25
Dec. 31.	J. S. Shaw.....	.....	16 38	16 38
Dec. 31.	C. G. Montgomery (Sept.)..	25 00	22 75	47 75
Dec. 31.	B. M. Sims (Nov.).....	10 00	11 79	21 79
Dec. 31.	J. G. Lewis.....	45 00	22 22	67 22

1905.		Salary.	Expenses.	Total.
Jan. 30.	J. G. Lewis.....	$45 00	$2 00	$ 47 00

		Salary.	Notary Fee.	Total.
Jan. 31.	J. S. Shaw.....	40 00	25	40 25
Feb. 28.	J. S. Shaw.....	40 00	25	40 25
Mar. 30.	J. S. Shaw.....	60 00	25	60 25

		Salary.	Expenses.	Total.
April 29.	J. S. Shaw.....	60 00	57 30	117 30
April 29.	Hargis Hill.....	20 00	37 65	57 65
April 29.	K. K. Kevil.....	10 00	16 80	26 80
May 31.	J. S. Shaw.....	60 00	73 35	133 35
May 31.	K. K. Kevil.....	20 00	22 60	42 60
May 31.	Hargis Hill.....	20 00	35 95	55 95
June 3.	Hargis Hill.....	20 00	29 70	49 70
June 3.	K. K. Kevil.....	12 00	17 00	29 00
June 3.	W. W. Shelby, Jr.....	8 00	14 60	22 60
June 3.	J. S. Shaw.....	60 00	79 95	139 95

1905.		Salary.	Expenses.	Total.
Aug. 3.	O. R. Kroell	30 00	24 05	54 05
Aug. 3.	W. W. Shelby, Jr	20 00	29 90	49 90
Aug. 3.	J. S. Shaw	60 00	71 85	131 85
Aug. 9.	Hargis Hill	25 00	38 25	63 25
Aug. 31.	W. W. Shelby, Jr	12 30	17 15	29 45
Sept. 4.	J. S. Shaw	60 00	120 70	180 70
Sept. 29.	O. R. Kroell	5 00	7 03	12 03
Oct. 3.	J. S. Shaw	60 00	10 55	70 55
Oct. 31.	J. S. Shaw	60 00	.....	60 00
Nov. 28.	J. S. Shaw	60 00	.....	60 00
Total, April 1, 1904, to December 1, 1905				$3,242 91

SHORT STATEMENT OF FOREGOING.

Year.	Salaries.	Expenses.	Totals.
1904	$887 85	$780 63	$1,668 48
1905	867 30	707 13	1,574 43
Totals	$1,755 15	$1,487 76	$3,242 91

OFFICE ACCOUNT.

1904.		
April 30.	M. M. Kelly, stenographer, pay for April	$ 30 00
May 31.	M. M. Kelly, stenographer, pay for May	31 00
June 30.	C. L. Jones, Secretary, pay for June	66 66
June 30.	C. L. Jones, Secretary, expenses for June	6 90
June 30.	Telegram to Foerste, May 12, from Director's account	25
June 30.	Telegram to Foerste, May 13, from Director's account	92
June 30.	Telegram to Wright, June 6, from Director's account	25
June 30.	Glue, June 21, from Director's account	10
June 30.	Telephone message to Frankfort June 23, from Director's account	25
June 30.	Glue, June 29, from Director's account	20
July 31.	C. L. Jones, Secretary, pay for July	66 67
July 31.	Telegram July 2, from Director's account	29
July 31.	Telegram July 6, from Director's account	25
July 31.	Telegram July 21, from Director's account	25
Aug. 4.	Postage stamps, $20, and notary fee, 20 cents, from Director's account	20 20
Aug. 31.	C. L. Jones, pay for August	66 67
Aug. 31.	Transylvania Co., July 13, 500 shipping tags	30
Aug. 31.	Transylvania Co., Aug. 1, box photo films	70

1904.			
Aug.	31.	Transylvania Co., flange for camera lens, $1; front board, 40c; 2 dozen photo plates, $1; express both ways, 50c	2 90
Aug.	31.	Postage stamps, July 26, from Director's account	2 00
Aug.	31.	Telegram, Aug. 22, Winchester and Louisville, from Director's account	70
Aug.	31.	Telegram, Shaw and Montgomery, Aug. 29, from Director's account	50
Sept.	30.	C. L. Jones, pay, $66.67 and expenses, $3.20, for September	69 87
Sept.	30.	Transylvania Co., 3 bottles drawing ink	75
Sept.	30.	Rent of telephone, $1 and tolls 95c for August, from Director's account	1 95
Sept.	30.	Broom, 30c; bucket, 25c; soap, 5c, September 21, from Director's account	90
Sept.	30.	Janitor's pay, one-half month, from Director's account.	10 00
Oct.	31.	C. L. Jones, pay for October	66 66
Oct.	31.	Jas. Mack, janitor, pay for October	20 00
Oct.	31.	Telegram October 5, from Director's account	35
Oct.	31.	Telephone rent and tolls for September, from Director's account	1 80
Nov.	5.	Telephone rent and tolls for October, from Director's account	1 75
Nov.	30.	C. L. Jones, pay, $66.67, and notary fee, 25c	66 92
Nov.	30.	Jas. Mack, janitor, pay, $20, and notary fee, 25c	20 25
Nov.	30.	Stenographer's note books, Transylvania Co., Oct. 10	10
Dec.	8.	Telephone rent, $1, and tolls, 85c, for November (Director's account)	1 85
Dec.	15.	Brower & Co., flat top desk	12 00
Dec.	15.	Brower & Co., Globe-Wernicke file, unit and top	11 50
Dec.	24.	C. L. Jones, pay, $66.66, and notary fee, 25c	66 91
Dec.	24.	Jas. Mack, pay, $20, and notary fee, 25c	20 25
Dec.	31.	Transylvania Co., December 14, journal record book	2 15
Dec.	31.	J. M. Byrnes, one-half dozen invoice files, $2.20; pamphlet file, 50c	2 70
1905.			
Jan.	2.	Telegram to Pate, December 15, from Director's account	25
Jan.	2.	Telegram to Foerste, December 23, from Director's account	25
Jan.	2.	Rent telephone No. 1012, $1, and tolls, $1, for December, from Director's account	2 00
Jan.	2.	Rent telephone No. 1540, for quarter ending March 31, from Director's account	5 70
Jan.	2.	Telegram, Grider, from Director's account	25
Jan.	31.	C. L. Jones, pay, $66.67, and notary fee, 25c, for January	66 92
Jan.	31.	Jas. Mack, janitor, pay for January	25 00

1905.			
Feb.	1.	Transylvania Co., January 2, duster, 35c; box tacks, 10c; waste basket, 25c. January 7, benzine, 10c; stencil paper, $2; mineral ink, $1.20	4 00
Feb.	1.	P. O. Box rent, January 6, from Director's account	1 00
Feb.	2.	Telephone No. 1012 rent, $1, and tolls, $5, for January	6 00
Feb.	28.	C. L. Jones, pay for February	75 00
Feb.	28.	James Mack, janitor, pay, $25, and notary fee, 25c, for January	25 25
Feb.	28.	C. L. Jones, expenses of two trips to Frankfort from Lexington, January 25-27 and February 15, on office business, $3.90, and notary fee, 25c	4 15
Feb.	28.	Postage stamps, February 27, from Director's account	10 00
Feb.	28.	Rent telephone No. 1012 for February, from Director's account	1 00
Mar.	30.	James Mack, janitor, pay for March and notary fee	25 25
Mar.	30.	C. L. Jones, Secretary, pay for March and notary fee	75 25
April	22.	C. F. Brower & Co., Globe-Wernicke book cases, 20 units, March 27 and April 7	78 00
April	29.	C. L. Jones, pay and notary fee for April	75 25
April	29.	Jas. Mack, pay and notary fee for April	25 25
April	29.	Items from Director's account as follows:	
		March 3, telegram, Hopkinsville	25
		April 1, rent of phone No. 1540 quarter ending June 30	6 00
		April 3, telegram, Marion	35
		April 5, P. O. Box rent, quarter ending June 30	1 00
		April 20, rent telephone No. 1012, $1, and tolls, $2.40 for March	3 40
		April 20, telegram, Milton, Wis	68
May	1.	Rent telephone No. 1012, $1, and tolls, $2.20, for April, from Director's account	3 20
May	8.	Transylvania Co., April 8, gummed labels, 25c; April 19, one-half dozen pencils, 50c	75
May	9.	F. C. Elkin, postmaster, postage stamps	20 00
May	9.	Secretary of State, notary commission	2 00
May	16.	J. M. Byrnes, pads of yellow writing paper	1 25
May	19.	J. H. Bean, notary seal, $3; rubber stamp, 50c	3 50
May	30.	C. L. Jones, pay for May	31 20
May	30.	Jas. Mack, pay for May	25 00
June	29.	C. L. Jones, pay for June	75 00
June	29.	Jas. Mack, pay for June	25 00
July	31.	Transylvania Co.'s account June 30, box pens, $1; holder, 5c	1 05
July	31.	C. L. Jones, pay for July	75 00
July	31.	Jas. Mack, pay for July	25 00

1905.			
July	31.	Items from Director's account as follows:	
		May 20, stenographer 1¾ days	1 75
		June 3, telegram to Pate	25
		June 12, telegram to Foerste	85
		June 23, telegram to Grider	35
		June 30, transfer wagon	35
		July 1, rent telephone No. 1540 for quarter ending September 30	5 70
		July 1, rent telephone No. 1012, $1, and tolls, $1.25, for May	2 25
Aug.	31.	C. L. Jones, pay for August	75 00
Aug.	31.	Jas. Mack, pay for August	25 00
Sept.	6.	Roger Harp and Bro., account rendered September:	
		August 1, 3 bars soap, 1 broom, spool of wire, box tacks	75
		August 24, 1 broom	35
Sept.	27.	C. L. Jones, pay for September	50 00
Sept.	29.	Jas. Mack, pay for September	25 00
Oct.	4.	Items from Director's account as follows:	
		July 3, 2 telegrams	54
		July 7, P. O. Box rent quarter ending September 30	1 00
		July 20, map purchased from U. S. Geological Survey	25
		July 24, Sam Coleman, labor	1 00
		August 1, telephone No. 1012 rent, $2, and tolls, $1.20, June and July	3 20
		October 1, telephone No. 1540 rent, quarter ending December 31	6 00
		October 3, P. O. Box rent, quarter ending December 31	1 00
		October 3, postage stamps	1 00
Oct.	31.	Jas. Mack, pay for October	25 00
Nov.	20.	Transylvania Co., April 18, 500 tags by Jones	60
Nov.	28.	Jas. Mack, pay for November	25 00
		Total, April 1, 1904, to December 1, 1905	$1,734 26

CHEMICAL ANALYSIS AND TESTING.

1904.			
Oct.	1.	A. M. Peter, analyses to date	$130 00
Nov.	30.	A. M. Peter, analyses in November	79 00
Dec.	31.	A. M. Peter, analyses in December	100 00

1905.				
Feb.	3.	A. M. Peter, analyses in January		70 00
April	4.	Anderson and Faig, testing 3 specimens of stone		6 00
May	9.	A. M. Peter, preparing Chemical Bulletin		100 00
July	14.	A. M. Peter, analyses February 1 to July 2		94 50
Aug.	17.	A. M. Peter, analyses in July		66 50
Sept.	1.	W. E. Burk, bill rendered for 17 analyses		160 00
		Total, April 1, 1904, to December 1, 1905		$806 00

ACCOUNT OF MUSEUM.

1904.				
April	22.	S. M. Brown, repairing cases		$49 50
May	20.	S. M. Brown, repairing cases		37 50
May	20.	S. M. Brown, painting cases, $2.50; making ladder, $2.95		5 45
June	9.	H. B. Pope, work in Museum, 3 days		3 00
June	30.	R. B. Sadler, work in Museum, 17½ days		17 50
July	31.	R. B. Sadler, work in Museum, 25 days		25 00
Aug.	31.	R. B. Sadler, work in Museum, 26½ days		26 50
Sept.	3.	R. B. Sadler, work in Museum, 3 days		3 00
Nov.	10.	A. Mitchell, work in Museum, from Director's account.		50
Dec.	8.	3 jugs, 35c; telegram, 51c, from Director's account		86
1905.				
Feb.	1.	R. Hays & Bro., January 31, bucket, mops, turpentine, 2 bars soap		1 45
Feb.	10.	Amount charged by Kentucky World's Fair Commission for shipping part of Kentucky mineral exhibit at close of Fair to State Geological Museum	$100 00	
Feb.	10.	Paid by Survey for unloading, hauling, etc. (See Freight, etc.)	44 80	
		Check sent Commission for balance		55 20
Oct.	4.	Thomas Churchill, labor 2½ days, from Director's account		2 50
Dec.	6.	Smith, Watkins & Co., wire and tacks		50
		Total, April 1, 1904, to December 6, 1905		$228 46

FREIGHT AND DRAYAGE.

1904.			
June	28.	J. H. Hostetter, freight, 66c; drayage, 75c, from Director's account	$ 1 41
July	12.	Adams Express Co., bill for June	2 10
Aug.	1.	Adams Express Co., bill to July 19	85

1904.				
Sept. 10.	Adams Express Co., bill to August 10			13 64
Oct. 12.	Adams Express Co., bill for September			26 55
Nov. 16.	Adams Express Co., bill for October			9 05
Dec. 1.	Adams Express Co., bill for November			6 31
1905.				
Jan. 21.	J. H. Hostetter, unloading and placing in Museum mineral specimens, cases, etc., sent from Kentucky mineral exhibit at World's Fair by Kentucky World's Fair Commission, this being part payment of $100 charged by the Commission for shipping the material to the Museum. (See also Museum account)			44 80
Jan. 21.	J. H. Hostetter, freight and drayage as follows:			
	December 8, 1904, drayage on box of stone.	$0 25		
	December 28, 1904, freight, 28c; drayage, 25c on box of stationery	53		
	January 20, 1905, freight, 96c; drayage, 50c on 2 boxes of pictures from Frankfort.	1 46		
				2 24
Jan. 28.	Adams Express Co., bill November 29, 1904, to January 24, 1905			7 45
Mar. 25.	Adams Express Co., bill for March			5 87
April 29.	Adams Express Co., bill for April			5 54
May 16.	J. H. Hostetter, drayage on mineral specimens, February 1, to May 16			1 75
June 29.	Adams Express Co., bill April 28 to June 29			8 50
Aug. 1.	Adams Express Co., bill June 27 to July 17			5 25
Sept. 6.	Adams Express Co., bill July 28 to August 19			4 48
Sept. 29.	Adams Express Co., expressage on surveying rods from Marion			1 50
Nov. 20.	Farley Transfer and Storage Co., freights and cartage as follows:			
	March 7, freight and cartage on box of stones	$0 25		
	April 4, freight and cartage on sack of stones	81		
	April 5, freight and cartage on sack of stones	81		
	April 6, freight and cartage on sack of stones	78		
	August 8, freight and cartage on sack of stones	91		
				3 56
Nov. 28.	Adams Express Co., bill October 16 to November 2			90
	Total, April 1, 1904, to December 1, 1905			$151 75

EQUIPMENT, REPAIRS AND SUPPLIES.

1904.			
June 6.	Keuffel & Esser Co., "Y" level, $85; barometer, $26.64; hand level, $5.60	$117	24
June 15.	Keuffel & Esser Co., roll profile paper, $6.30; small "Y" level, $85; plumb bob, 18 oz., $1.12	92	42
June 30.	A. M. Miller, photo plates, May 13, from Director's account	2	25
July 2.	Keuffel & Esser Co., 2 Phila rods	20	80
July 11.	McAdams & Morford, 6 gross bottles and corks for well samples	14	40
July 16.	Queen & Co., repairing 2 barometers	10	25
July 27.	Keuffel & Esser Co., 2 aneroid barometers	33	60
July 27.	Keuffel & Esser Co., 2 Harvard compasses in cases, $7.30; 1 dozen field books, $3.50; 1 dozen level books, $3.15	13	95
Aug. 25.	Keuffel & Esser Co., small transit	93	50
Aug. 29.	Keuffel & Esser Co., repairing large transit	13	50
Oct. 12.	Keuffel & Esser Co., repairing large transit	27	00
Oct. 19.	M. H. Crump, 1 transit, $110; 1 level, $90	200	00
Oct. 31.	Keuffel & Esser Co., 2 Florida rods	16	00
Nov. 30.	Keuffel & Esser Co., roll drawing paper, $6.20; 10 yards drawing paper, $2.45; roll tracing cloth, $10.42; 4 card protractors, 82c	19	89
1905.			
Feb. 27.	Keuffel & Esser Co., 1 pint Columbia ink, $2; 1 steel tape, $8.27; hand level, $5.60; paper cutter, 24c; "metallic" tape, $1.51; spring bow pen, $1; drawing pen, 98c; railroad pen, $2.63; sponge rubber, 42c; erasing shield, 17c	22	82
April 29.	Keuffel & Esser Co., 2 barometers, $43.44; small steel tape, $2.25; hand level, $5.60; set "Key" brand drawing instruments, $8.47; 1 railroad pen, $1.67	61	43
May 8.	Transylvania Co., Star Primo camera, $22.50; Zeiss lens, $52.40; film adapter, $1; 6 plate holders, $6; tripod, $3; film pack, 70c; 1 dozen photo plates, 40c	86	00
May 16.	J. M. Byrnes, paper bags for samples		45
June 30.	L. M. Prince, drawing paper	8	75
June 30.	Transylvania Co., 3 field books	1	50
	Total, April 1, 1904, to December 1, 1905	$855	75

CONDENSED STATEMENT.

For the year 1904	$674	80
For the year 1905	180	95
Total	$855	75

DIRECTOR'S ACCOUNT.

1904.				
May	30.	Railroad fares for April and May.....		$ 8 20
May	30.	Items paid by Director, but carried to other accounts:		
		April and May telegrams (to Office acct.)..	$1 17	
		May 13, A. M. Miller, for photo plates (to Equip., etc., account).....	2 25	
			$3 42	
June	30.	Railroad fares for June.....		1 70
June	30.	Items paid by Director, but carried to other accounts:		
		June 6, telegram (to Office account).....	$0 25	
		June 21, glue (to Office account).....	10	
		June 23, telephone message (to Office account)	25	
		June 28, J. H. Hostetter, freights and drayage (to Freight account).....	1 41	
		June 29, glue (to Office account).....	20	
			$2 21	
Aug.	2.	Field expenses, July 2 to August 2.....		61 74
Aug.	2.	Items paid by Director, but carried to other accounts:		
		July 2, telegram (to Office account).....	$0 29	
		July 6, telegram (to Office account).....	25	
		July 21, telegram (to Office account).....	25	
		July 21, broad hatchet (to Mapping acct.).	1 25	
		July 22, L. Ayres, axman (to Mapping acct.)	6 40	
			$8 44	
Aug.	4.	Postage stamps (to Office account).....	$20 00	
Aug.	30.	Notary fee (to Office account).....	20	
			$20 20	
Aug.	30.	Field expenses for August.....		16 05
Aug.	30.	Items paid by Director, carried to other accounts:		
		July 26, postage stamps (to Office account).	$2 00	
		Aug. 22, 2 telegrams (to Office account)....	70	
		Aug. 29, telegram (to Office account).....	50	
			$3 20	
Sept.	30.	Field expenses for September.....		26 14

1904.				
Sept. 30.	Items paid by Director, carried to other accounts:			
	Sept. 8, telephone rent, $1, and tolls for August, 95c (to Office account).....	$1 95		
	Sept. 21, broom, 30c; mop, 30c; bucket, 25c; soap, 5c (to Office account).....	90		
	Sept. 30, janitor, ½ month (to Office acct.).	10 00		
		$12 85		
Nov. 5.	Field expenses October 1 to October 31, inclusive.....			10 30
Nov. 5.	Items paid by Director, carried to other accounts:			
	Oct. 5, telegram (to Office account).....	$0 35		
	October 12, telephone rent, $1, and tolls, 80c, for September (to Office account).....	1 80		
	Nov. 2, A. Mitchell, work in Museum (to Museum account)	50		
	Nov. 5, telephone rent, $1, and tolls, 75c, for October (to Office account).....	1 75		
		$4 40		
Dec. 7.	Traveling expenses, November 29 and December 4.....			7 95
Dec. 7.	Items paid by Director, carried to other accounts:			
	Nov. 14, 3 jugs (to Museum account).....	$0 35		
	Dec. 6, telegram, account mineral exhibit (to Museum account).....	51		
	Dec. 7, telephone rent, $1, and tolls, 85c for November (to Office account).....	1 85		
		$2 71		
1905.				
Jan. 2.	Traveling expenses, December 19 to 31.....			9 86
Jan. 2.	Items paid by Director, carried to other accounts:			
	Dec. 15, telegram (to Office account).....	$0 25		
	Dec. 23, telegram (to Office account).....	25		
	Jan. 2, telephone rent, $1, and tolls, $1, for December (to Office account).....	2 00		
	Jan. 2, telephone No. 1540, rent for quarter ending March 31 (to Office account)...	5 70		
	Jan. 2, telegram (to Office account).....	25		
		$8 45		
Feb. 2.	Traveling expenses for January.....			10 60

1905.				
Feb.	2.	Items paid by Director, carried to other accounts:		
		Jan. 6, P. O. Box rent, quarter ending March 31 (to Office account)	$1 00	
		Feb. 2, telephone No. 1012 rent, $1, and tolls, $5, for January (to Office account)	6 00	
			$7 00	
Feb.	28.	Traveling expenses for February		2 05
Feb.	28.	Items paid by Director, carried to other accounts:		
		Feb. 27, postage stamps (to Office account)	$10 00	
		Feb. 28, telephone No. 1012, rent for February (to Office account)	1 00	
			$11 00	
May	2.	Traveling expenses in April		4 00
May	2.	Items paid by Director, carried to other accounts:		
		March 3, telegram (to Office account)	$0 25	
		April 1, telephone No. 1540, rent for quarter ending June 30 (to Office account)	6 00	
		April 3, telegram (to Office account)	35	
		April 5, P. O. Box rent, quarter ending June 30 (to Office account)	1 00	
		April 15, ½ gross vials for drillings (to Geology account)	50	
		April 20, telephone No. 1012 rent, $1, and tolls, $2.40, for March (to Office acct.)	3 40	
		April 20, telegram (to Office account)	68	
		May 1, telephone No. 1012 rent, $1, and tolls, $2.20 for April (to Office account)	3 20	
			$15 38	
July	3.	Traveling expenses in May		6 20

1905.				
July	3.	Items paid by Director, carried to other accounts:		
		May 20, stenographer, 1¾ days (to Office account)	$1 75	
		June 3, telegram (to Office account)	25	
		June 12, telegram (to Office account)	85	
		June 22, telegram (to Office account)	35	
		June 30, transfer wagon (to Office acct.)	35	
		July 1, telephone No. 1540, rent quarter ending September 30 (to Office acct.)	5 70	
		July 1, telephone No. 1012, rent, $1, and tolls, $1.25, for May (to Office acct.)	2 25	
			$11 50	
Oct.	4.	Traveling expenses August and September		6 20
Oct.	4.	Items paid by Director, carried to other accounts:		
		July 3, telegrams (2) (to Office account)	$0 54	
		July 7, P. O. Box rent, quarter ending September 30 (to Office account)	1 00	
		July 12, T. Churchill, work in Museum (to Museum account)	2 50	
		July 20, U. S. Geological Survey, 1 map (to Office account)	25	
		July 24, Sam Coleman, 10 hours work in office (to Office account)	1 00	
		Aug. 1, telephone No. 1012, rent June and July, $2, and tolls, $1.20 (to Office acct.)	3 20	
		Oct. 1, telephone No. 1540, rent quarter ending December 31 (to Office account)	6 00	
		Oct. 3, P. O. Box rent, quarter ending December 31 (to Office account)	1 00	
		Oct. 3, postage stamps (to Office account)	1 00	
			$16 49	
		Total field expenses, April 1, 1904, to October 4, 1905		$170 99
		Total items paid and carried to other accounts, April 1, 1904, to October 4, 1905	$127 25	

U. S. GEOLOGICAL SURVEY ACCOUNTS.

CO-OPERATIVE TOPOGRAPHIC SURVEYING.

1904.		Totals.
April 30.	J. R. Ellis, pay-roll for April	$ 27 00
April 30.	J. R. Ellis, field expenses for April	51 75
April 30.	J. R. Ellis, miscellaneous traveling expenses	35 85
May 31.	J. R. Ellis, pay-roll, $135, and expenses, $337.51	472 51
May 31.	W. L. Miller, pay-roll for May	147 10
May 31.	W. L. Miller, expenses for May	457 66
June 24.	J. R. Ellis, June pay-roll	112 00
June 25.	J. R. Ellis, field expenses for June	183 73
June 30.	W. L. Miller, field and miscellaneous traveling expenses for June	409 76
June 30.	C. A. Clunet, pay June 16 to 30	35 00
July 15.	C. A. Clunet, pay July 1 to 15	35 00
Aug. 1.	W. L. Miller, July pay-roll	296 00
Aug. 12.	W. L. Miller, traveling and miscellaneous expenses for July	36 95
Aug. 15.	R. W. Berry, traveling and miscellaneous expenses for July	26 25
Aug. 22.	W. L. Miller, field expenses for July	330 43
Sept. 1.	W. L. Miller, August pay-roll	430 00
Sept. 1.	W. L. Miller, field and miscellaneous traveling expenses for August	304 23
Sept. 1.	R. W. Berry, miscellaneous traveling expenses for Aug.	85 30
Oct. 1.	W. L. Miller, September pay-roll	435 00
Oct. 15.	R. W. Berry, expenses for October	85 14
Nov. 1.	W. L. Miller, October pay-roll	196 84
Dec. 22.	W. W. Johnson, care of U. S. Survey animals	77 90
Dec. 22.	J. W. Newman, care of U. S. Survey wagons, etc	16 94
1905.		
Jan. 30.	W. A. Cooke, storage, $10, and loading, $2.75, U. S. Survey property	12 75
Jan. 31.	J. R. Ellis, salary for January	100 00
Jan. 31.	W. L. Miller, salary for January	133 33
Feb. 28.	W. L. Miller, salary for February	133 33
Mar. 31.	W. L. Miller, salary for March	133 34
April 25.	W. H. S. Morey, pay April 1 to 24	56 00
May 20.	Chas. E. Cooke, expense account for May	211 50
June 13.	Chas. E. Cooke, May pay-roll	288 98
June 13.	C. H. Bliss, livery bill (for C. E. Cooke and party) May.	108 75
June 13.	J. S. B. Daingerfield, field expenses for May	89 45
June 13.	L. Scott Smith, expense account for May	96 20
July 10.	C. H. Bliss, livery bill (C. E. Cooke and party) June	98 00
July 10.	Chas. E. Cooke, June pay-roll	300 00
July 15.	Chas. E. Cooke, expense account for June	445 84

1905.			
July	15.	J. S. B. Daingerfield, expenses for June	85 45
Aug.	1.	Chas. E. Cooke, July pay-roll	300 00
Aug.	9.	L. Scott Smith, July expenses	92 75
Aug.	9.	J. S. B. Daingerfield, July expenses	143 09
Aug.	9.	O. B. Ellis, livery bill (for C. E. Cooke and party) July.	60 00
Aug.	17.	Chas. E. Cooke, expenses June 14	3 00
Aug.	17.	Chas. E. Cooke, July expenses	506 60
Aug.	17.	C. H. Bliss, livery (for C. E. Cooke and party) July)	30 00
Sept.	6.	C. E. Cooke, August pay-roll	310 00
Sept.	6.	O. B. Ellis livery bill (for C. E. Cooke and party) Aug.	61 50
Sept.	14.	C. E. Cooke, August expenses	383 19
Sept.	14.	L. B. Daingerfield	114 03
Sept.	14.	Matt. Winn, livery bill (for Sallee and others) August.	52 50
Sept.	14.	C. H. Bliss, livery bill (for Daingerfield) August	10 00
Sept.	14.	L. S. Smith, August expenses	92 05
Oct.	3.	L. S. Smith, September expenses	13 74
Oct.	3.	C. B. Kendall, September pay-roll	150 50
Oct.	3.	C. E. Cooke, September pay-roll	280 00
Oct.	16.	C. B. Kendall, September expenses	102 69
Oct.	16.	W. H. Snyder, pay, rodman in September	26 00
Oct.	16.	J. H. McKee, livery bill (for C. B. Kendall) September.	31 50
Oct.	16.	J. S. B. Daingerfield, September expenses	106 05
Oct.	16.	W. J. Lloyd, September expenses	53 85
Oct.	16.	C. E. Cooke, September expenses	391 50
Nov.	20.	C. E. Cooke, October expenses	41 70
Nov.	20.	W. H. Sallee, pay, 17 days in October	34 00
		Total, April 1, 1904, to December 1, 1905	$9,971 50

SUMMARY.

Allotment for State organization work, 2 years	$20,000 00
Expended in 1904 and 1905, to December 1	19,358 63
Balance to credit State organization work	$641 37
Allotment for U. S. Geological Survey co-operation, 2 years	$10,000 00
Expended in 1904 and 1905, to December 1	9,971 50
Balance to credit U. S. Geological Survey December 1	$28 50

APR 6 1909

Kentucky Geological Survey

CHARLES J. NORWOOD, Director.

REPORT

ON THE

Progress of the Survey

FOR THE YEARS 1906 AND 1907.

By CHARLES J. NORWOOD.

LEXINGTON, KENTUCKY.

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LETTER OF SUBMITTAL.

To His Excellency, AUGUSTUS E. WILLSON,

Governor of Kentucky.

Sir: I have the honor to submit the following report on the progress of the Geological Survey for the years 1906 and 1907 for your consideration, and for transmittal to the General Assembly. Very respectfully,

CHARLES J. NORWOOD,

Director, Kentucky Geological Survey.

LEXINGTON, KY., December 6, 1907.

PERSONNEL OF THE SURVEY.

The following persons are now, or have been, employed on the Survey, named in the order of their appointment under each class:

Director.—Charles J. Norwood.

Assistants in Geology.—Joseph B. Hoeing (also Cartographer), Arthur M. Miller, Aug. F. Foerste, W. F. Pate (1906), Albert R. Crandall, James H. Gardner (resigned August 1, 1906), Samuel A. Denny (parts of 1906 and 1907), F. Julius Fohs, and James M. Hodge. Mr. L. N. Taylor served as field aid for part of 1906.

Chemistry and Technology.—Alfred M. Peter, chief chemist and in charge of soil testing; Franklin E. Tuttle, chemist for part of 1907; Harry D. Easton, assistant in technology of clays, etc.; J. S. McHargue, chemist.

Miscellaneous.—F. Grider McKay, clerk; George F. Brockman, topographic aid in 1906, aid in technology and field aid soil survey in 1907; William W. Shelby, Jr., topographic aid in 1906, head of field party in oil well survey in 1907; Wallace Newberger, compiling revised chemical report and drafting; N. D. Bentley, copyist; Percy S. Wilson, draftsman in 1907 (resigned); Graham Edgar, field aid in soil survey in 1907.

Topographic.—Joseph S. Shaw, assistant (resigned in May, 1906); Henry B. Pope, assistant (resigned in March, 1907); James W. Norton and Sterling B. Price, field aids in 1907.

Other persons were employed occasionally, during the time covered by this report, but only for brief periods.

In the co-operative topographic mapping large field parties, under the direction of topographers of the U. S. Geological Survey, were employed. It is not deemed necessary to give the long list of names here.

REPORT OF PROGRESS.

The law which governs the Survey requires that our mineral resources shall first be studied by subjects, and bulletins thereon be issued as rapidly as they can be prepared, after which shall come detailed reports on the counties; also, that the soils, timbers and water-powers shall be reported upon, and that topographic mapping of the State shall be carried on. To meet this requirement and cover the various mineral deposits known to occur in the State (irrespective of those that may be discovered in the course of exploration), bulletins must be issued on the following subjects: Bituminous coals (domestic, steam, cannel, etc.), clays fit for various purposes, cement materials (natural and Portland), structural and other stones, road materials (including asphalt rock, dike rocks, Devonian black shale, gravel beds, limestones, etc.), lead, zinc and iron ores, polishing materials, petroleum, and natural gas (and materials from which fuel gas can be cheaply made), potash shales and earths, phosphatic limestones and shales, mineral waters (including those carrying domestic salt, Crab Orchard salts, bromine and lithia), pure water and water horizons, fluorspar, heavy spar (barite) and calcspar, pigment earths and ores, sands (for moulding, plaster, glass, brick, etc.), timbers, water-powers, etc. The Survey is striving to comply with the requirements in the fullest way possible under the limitations which at present control its plans; seventeen bulletins have been completed, five are nearly ready for the printer, and material for others has in part been collected. Expedition has been urged upon all members of the Survey, and they have responded in a manner that is most gratifying.

It is believed that the work accomplished by the Survey since its re-establishment in 1904 will well bear comparison, both as to quantity and quality, with that of other Surveys, and had the printing of completed reports kept pace with their preparation a larger number of bulletins would be

ready for distribution than may now be named. It must be admitted, however, that as a result of the driving necessity for quick reports, it has not been possible in some instances to give that degree of finality to bulletins that, for a thorough statement of our resources, must eventually be reached. So long as the plans of the Survey must be confined within the limits of biennial appropriations, this difficulty will continue. The maintenance of the Survey until full and thorough reports shall have been made on all our mineral deposits and on all the counties is a business necessity, and better results will be obtained with a continuous annual appropriation, even though of smaller amount, than if plans must be cut to suit the limits of uncertain biennial appropriations. It is therefore recommended that a continuous annual appropriation be made for the Survey.

The work of the Survey comes under four heads, namely, geological, topographical agricultural (or soil survey), and chemical and technological. Following is a report of the subjects covered during the past two years:

THE COAL FIELDS.

At no time has greater interest been manifested in our coalfields than now, and it is of a less speculative nature than hitherto. A large amount of capital is being placed in both fields for development purposes, and more is seeking investment. The recent decision of our Court of Appeals, giving stability to land titles in the Eastern Field, will doubtless make for the development of large areas of that field that otherwise would have lain idle. A marked feature of the correspondence of the Survey is the interest manifested in our coalfields, Western as well as Eastern, by Pennsylvania and West Virginia capital. The rising value of coal territory is illustrated by a statement which recently appeared in one of the trade journals. It is stated that in 1896 coal lands in the very best of the Pittsburg seam, at all distant from railroads, could hardly be sold for six to ten dollars per acre, whereas they are now eagerly sought at greatly increased figures; that in 1899 lands near rail and water sold for $30.00 and $100.00 per acre, as the "top notch," whereas in 1901 and 1902

options were taken at $90.00 and $130.00 an acre. Moreover, that prices have gone as high as $600 and $700 an acre where $100 would have been high in 1901, and $150 high even in 1905.

Coals of the Licking Valley.—Prof. A. R. Crandall, for a short time assisted by Mr. Denny, has completed the field work and report on this region, which covers an area of about 900 square miles. Necessarily the report covers some contiguous territory, and therefore includes Morgan, Magoffin, and parts of Breathitt, Wolfe, Menefee and Elliott counties. The report shows a finer field of bituminous coal, in addition to the cannels, in the district covered than has hitherto been known.

The Pineville, Log Mountain, Barbourville District.—The field work in this district, which lies in Bell and Knox counties, was completed in 1907, and the report is ready for the printer. This is the joint work of Mr. G. M. Sullivan and Prof. Crandall, Mr. Sullivan having covered a considerable part of the ground in previous years. An area of about 200 square miles is included. Correlations of certain coals that appear on both sides of Pine Mountain were made, thus materially simplifying the work of the engineer engaged in opening up the coals of the district.

Upper Cumberland River District.—Mr. James M. Hodge, assisted for a time by Mr. J. H. Gardner, has completed field work on the Poor and Clover Forks of the Cumberland river, in Harlan and Letcher counties, covering practically the whole of the Big and Little Black Mountains in Kentucky and embracing an area of about 350 square miles. The report is nearly ready for the printer, but it is doubtful whether it can be completed before the Spring of 1908, since the large amount of detail renders its preparation slow and laborious. The work in this almost unknown but great region was thoroughly done, and the report should prove very helpful in forwarding the development of that part of the State. The total number of workable beds determined is about twelve, including an exceptionally fine coal, five to six feet in thickness, with little or no parting, hitherto but little known. The total number of coal seams of all thicknesses found in the field is about forty. With the completion of Mr. Hodge's work cov-

ering the upper twenty-five miles of the valley, together with the work of Dr. Ashley and Dr. Glenn in the stretch from Harlan C. H. to Middlesboro, done in 1902, and the work of Mr. Sullivan and Mr Crandall in the Log Mountain area, the whole of the Cumberland river region south of Pine Mountain has now been covered, and the value of one of the greatest of our coal regions will become fully known.

The Three Forks of the Kentucky River.—The coals of the region drained by the Three Forks of the Kentucky river have been studied by Mr. Hodge, and his report is ready for the printer. Much was found to add to the preliminary report made by Mr. Hodge some years ago. A brief summary of the report, prepared by Mr. Hodge, is given in the Appendix to this report. Much interest has been manifested in the coal values of the region, and this summary should prove helpful in determining the question of developing the territory in question. The report embraces an area of about 1,400 square miles

Coals of the Lower (Conglomerate) Measures on the Western Border of the Eastern Coalfield.—The study of this important and hitherto little understood strip was placed in the hands of Prof. A. M. Miller in the spring of 1906. Field work was completed in 1907. The report is ready for the printer, and two of the three large maps are ready for the engraver. The area covered embraces about 1,800 square miles. It embraces all the territory between the Cincinnati Southern and Louisville & Nashville railroads, with additional ground on either side, and includes more or less of Pulaski, Whitley, Laurel, Rockcastle, Jackson, Owsley, Lee, Menefee, Wolfe, Powell and Estill counties. One of the most important features of the report is the correlation of the several coals that occur within its limits. A summary, prepared by Prof. Miller, is given in the Appendix to this report.

Coals of the Western Coalfield.—This work is in the hands of the Director, who has been assisted by Mr S. A. Denny and, recently, by Mr. Fohs. It was expected that the work would be completed and the report made ready for the printer ere now, but the sudden and serious illness of Mr. Denny, which finally removed him permanently from the field,

has caused delay. Work has been carried on in Muhlenberg, Ohio, Hopkins, Henderson, Union, Daviess, McLean and Webster counties. One of the gratifying results of the past season's work is the definite determination of the extension of the "Henderson" coal over the larger part of Henderson county and into Daviess and Webster counties—as far west as Corydon, as far south as Sebree, and as far east as Birk City in Daviess county, possibly even farther east. Since this area is flat, with but few outcrops, it has been little understood hitherto. It is believed that the 5-foot coal now worked in the Keystone shaft at Henderson, which occurs about 283 feet below the "Henderson," is co-extensive with the "Henderson" bed. It has also been definitely determined that there are several workable coals above what is known in the Western Field as No. 12, and which has hitherto been regarded as the highest workable bed in the field.

THE ROUGH CREEK ANTICLINE.

It seems well to repeat the brief remarks made about this uplift in my report for 1904-'05. The anticline is part of a very important disturbance which apparently extends quite across the State, in an approximately east and west direction, from Shawneetown, Ill., to near Warfield, Martin county. It is important to know what relation it bears to the coals of the Western Field, especially in Ohio, McLean, Webster and Union counties, and its study is of value in prospecting for oil and gas. Prof. W. F. Pate began work on the disturbance in 1905, and it was hoped that he could continue the work in 1906 and complete it during 1907, but circumstances, complicated by a misunderstanding, intervened. It is hoped that the work may be resumed by Prof. Pate during the coming year and be carried to completion.

OIL AND GAS.

One of the most useful of the bulletins that has been issued by the Survey is the report on the Gas and Oil Sands of the State by Mr. J. B. Hoeing. Had such a report been available some years earlier, it would have pointed the way to more intel-

ligent drilling and would have rendered unnecessary much of the "wild catting" that has been carried on. It would be well, indeed, for those who are disposed to drill for oil in the north-central part of the State to consult this bulletin before undertaking experiments in a large way. The report shows that there are reasonably fair chances of obtaining good supplies of natural gas by deep drilling in that area, but that despite startling accounts of "50-barrel" wells in the "bluegrass region" and the actual finding of small quantities of oil here and there, the probabilities of obtaining petroleum in commercial quantities are small. In the production of crude petroleum, Kentucky, bracketed with Tennessee (which produces but a small proportion of the joint output), ranks about ninth among the eighteen oil producing States. It is believed that naturally it could rank higher. It has been asserted by Mr. W. T. Griswold, in a report on petroleum for the statistical division of the U. S. Geological Survey, that "the most probable area from whch an increased production of the Appalachian field may be obtained" is presented by Kentucky and Tennessee. It was expected that Mr. Hoeing would extend his field studies systematically westward, but the demands upon his time in the preparation of various maps, including the new geological map of the State, have prevented his doing so. The work of collecting data has been kept up by Mr. Hoeing as well as possible by correspondence, by the collection of records of new wells drilled, by occasional trips into the field, and by a number of special trips made for the purpose of giving aid in the field to oil operators. Many of the latter trips have been without expense to the State, but in all such cases the State has had the benefit of the notes and data secured. Records of drilled wells in addition to those already published have been secured from the counties of Allen, Barren, Bath, Bell, Christian, Cumberland, Fayette, Hopkins, Knox, Lee, Logan, Menefee, Morgan, Wayne, and Wolfe, and from some of the counties along the Ohio river in Indiana which give sections available for the Kentucky side as well. Field trips have been made in Barren, Breathitt, Bath, Fayette, Lee, Logan, Morgan, Wolfe and Knox counties. Field work for the underground survey of

the State was started in the season of 1907 and carried throughout the summer by Mr. W. W. Shelby and party under Mr. Hoeing's direction. The work consisted of level and transit lines connecting various wells and prominent surface points to enable them to be plotted and connected with sea level, and thus render possible the plotting of the different formations as found underground. The work began at Bowling Green, Warren county, was carried into Allen, Simpson and Barren counties, and ended for the season at Burksville, in Cumberland county.

During 1907 much interest was aroused by the finding of gas in shallow wells that had been bored for water on the farm of Mr. C. E. Downing, in Fayette county, and on that of Mr. Hardin Fields, in Woodford county. In view of the various publications concerning the discoveries, it was deemed well to issue an official note concerning them, which is here reproduced: "Since the discovery made by the State Geological Survey that natural gas occurs in commercial quantity in the Kentucky 'Calciferous' beds (the deepest rocks that have yet been penetrated in the State, and which nowhere come to the surface), it has encouraged deep boring for fuel gas in Central Kentucky wherever the structure seemed favorable. In addition, it has kept diligent watch for finds in the shallower rocks, in order that by systematic study of them a satisfactory 'working hypothesis' may be arrived at upon which prospecting may be carried on in an intelligent way. As a rule, the finds of gas in the shallower rocks in the central part of the State, though of rather frequent occurrence, are feeble flows from quickly exhausted pockets, which, though they might for some time supply sufficient gas for one or two households, have no general commercial importance. One should, therefore, be very conservative when forming an opinion as to the supplies of gas that may be derived from the shallower beds in the Blue Grass region. The Downing strike in Fayette is out of the ordinary; that on the farm of Mr. Fields, in Woodford, is doubtless representative of many others that have been made in the past, but which escaped general notice. Both have been examined by Mr. J. B. Hoeing, assistant geologist on the Survey, who still has them under observation. The

following brief statement concerning them has been prepared by Mr. Hoeing:

"'*The Downing Well.*—This gas well is on the farm of Mr. C. E. Downing, three miles south of Lexington, on the Nicholasville pike. The well was being drilled for a water supply, but without avail; gas, instead, was struck at a depth of 205 feet, and the well was drilled to a total depth of 220 feet. The well was started at about 20 feet above the base of the Winchester formation (the Lower Hudson of the old reports), and passes nearly through the Lexington (better known as Trenton), stopping in the Lexington a short distance above the Logana division, and probably about 60 feet above the Tyrone or Birdseye. No water at all was struck in the well, the gas being perfectly dry. The history of the numerous shallow wells in the blue grass region of Central Kentucky has shown them often to be shortlived and pockety. This well, so far, has proved to be an exception to the rule. It was allowed to blow off in the air for five days, showing in that time only a small diminution in volume and pressure. The rock pressure is higher than would be expected for the depth of the well, but was not measured. The volume, after flowing open for five days, was measured by the writer and gave 56,000 cubic feet in 24 hours. The well was then closed up and rested for three days and then opened and left open long enough to bring it down to the open pressure and measured, when the average of five careful measurements gave a volume of 65,000 cubic feet in 24 hours, with apparently no diminution in pressure. This, so far, is a remarkably good well for this section, and if it holds up to anything near its present production will prove quite profitable to the owner as a source of heat, power and light sufficient for the immediate neighborhood. It is to be regretted that so much of the gas was allowed to waste in the air; probably more than a year's supply for the owner's house went into the air during the time it was open. The well has been closed in and the owner will pipe the gas to his house and barn and use it for heat, and probably also attach coils to the main pipe for refrigerator.

"'*The Fields Well.*—This well is on the farm of Mr. Hardin Fields one mile east of Versailles, in Woodford county.

The well was drilled for water. It starts just below the top of the Lexington and is entirely in the upper part of that formation, being only 40 feet deep. Gas was struck at 16 feet, and apparently more a little deeper. A strong vein of water came in below the gas and stands 25 feet deep in the well. The well was fastened up in such way that at the time of the writer's visit the volume could not be measured. It is a small gas well, but there is enough gas there now to supply Mr. Fields' dwelling with light and heat. It is problematical as to whether this gas will last, but if it does hold out and the water does not drown it, the well will be used for a home supply of light and heat and possibly occasional power on the farm.' "

LEAD, ZINC, AND SPAR DEPOSITS.

Western Kentucky.—The field work for the general study of the lead, zinc, fluorspar and barite deposits of Western Kentucky was completed by Mr. Fohs and the report is ready for the printer. The report covers the counties of Caldwell, Crittenden, and Livingston, and parts of Christian, Lyon and Trigg, is in great detail, illustrated with many figures and plates, and accompanied by three large maps. In a brief summary referring to the deposits of the six counties, Mr. Fohs says:

"The conclusions reached concerning these deposits are, briefly: The fluorspar supply is practically inexhaustible; zinc ore occurs in more considerable quantity than previously supposed, and the assured solution of the milling problem should greatly increase its production; lead occurs in sufficient quantity with both the fluorspar and the zinc deposits to make a nice profit above what is secured from either type of deposit alone; large pure calcspar deposits occur which will repay mining; favorable conditions occur in parts of northern Christian, northern Lyon, northern Trigg and eastern Crittenden counties, thus extending the eastern, southeastern and southern limits of the district; chances for economic deposits appear less in the faults near the borders than those near center of field; chances along undeveloped portions of the main faults and their complementary fractures, especially in the limestone but also in the quartzite walls, are good and more

cross-cutting is advisable. One of the results of the work was the discovery of a simple method of determining the probable strikes of cross and intersecting complementary fractures, where the strike of one fault is known. Recent development work showed highly favorable results, many good ore shoots being found on old properties, both along the strike and in depth, along the faults."

A special report on the Kentucky Fluorspar Deposits has also been prepared by Mr. Fohs. This report describes the general occurrences of fluorspar in the State, its statistics up to 1907, the methods of mining, the technology of the mineral, etc. The report is in type and should soon come from the press.

Central Kentucky.—It was expected that the study of the vein deposits of the central part of the State would be completed by the end of 1907, but it could not be done, other work interfering. That the mining of barite, with lead and zinc as byproducts, will become quite an important industry in Central Kentucky seems beyond question. We may also expect the mining of fluorspar to assume importance whenever a cheap and ready means for separating barite and calcite from it may be found—a problem which the Survey now has in hand. The barite occurs in veins of considerable depth and linear extent, and not in "pockets" as has recently been stated by a writer in the public press. There is an abundance of the mineral in the counties forming central Kentucky—enough to last for very many years at the present rate of production in this country. It is believed that this region offers advantages over Virginia, where, according to the Engineering and Mining Journal "it is rather hard to accumulate sufficient barytes to run a good sized mill;" and it is significent that Virginia capital has come to this district and has erected a mill for handling the mineral. (The Jessamine Barytes Company, at Nicholasville). The Survey has succeeded in drawing attention to the district and many leases for mining barite have been effected. A general statement concerning the deposits was given in my report for 1904-'05, and other data will be found in the bulletin on fluorspar, now in type.

SOIL SURVEY.

What may be regarded as in some respects the most important work undertaken during 1907 is the soil survey. Preparatory work for this, in the way of classifying and mapping the rock formations, began in 1905. The object of the survey is to systematically sample and study the soils over the State so that a map may be prepared which will show the character of soil in the various regions. For the construction of such a map, the geology must be worked out first, so that the divisions of the different formations may be laid down; then a systematic course of sampling of the soils made by the various rock beds is carried on, and the samples are analyzed or otherwise treated with a view to determining for what plants the soils are best suited, or what the soils may need in the way of fertilizers to grow good crops of various sorts of plants. This work is being carried on in cooperation with the Director of the State Agricultural Station, the Survey doing the geology, collecting the samples, and doing the mapping, while the Station investigates the character and needs of the soils. The Station work is in the hands of Dr. A. M. Peter. The field work during 1907 was in the hands of Prof. Aug. F. Foerste, assisted by Mr. George F. Brockman and Mr. Graham Edgar. Too much can not be said in commendation of the work of these gentlemen. Nearly 700 samples were collected, chiefly from the Subcarboniferous (Mississippian) area, shown in two shades of blue on the State geological map, in the counties of Meade, Breckenridge, Grayson, Edmonson, Larue, Warren, Hart, Simpson, Logan, Todd, Christian, Trigg, Livingston, Lyon, Caldwell, Crittenden, Barren, Allen, Metcalfe, Adair, Green and Taylor, and from the more recent formations in Graves. Each other formation is to be similarly sampled as the work goes on, and all the counties covered. The methods of the field work, other than determinations of geology, with sundry comments, are described by Prof. Foerste in a summary which is given in the Appendix.

As part of the cooperative work with the Agricultural Experiment Station, it is proposed to carry out this winter and next spring a number of pot experiments with the soils collected by the Survey. These experiments will be conducted

by Dr. Peter. The first object of this investigation is to study and compare the manurial requirements of the principal types of agricultural land existing in the State. To this end, suitable plants, such as wheat, oats, peas or clover, will be grown in pots of the soil to be tested, both without any addition and with the addition of the important constituents of fertilizers, separately and in various combinations. For example: A series of eight pots might be arranged, No. 1 without addition; No. 2 with phosphate; No. 3 with potash salt; No. 4 with nitrate of soda; No. 5, phosphate and potash salt; No. 6, phosphate and nitrate of soda; No. 7 potash salt and nitrate of soda; and No. 8, phosphate, potash salt and nitrate. By comparing the growth of wheat in such a series of pots, it will usually be apparent which of the substances tried, taken singly, or which combination, has produced the best growth, and a general inference can be drawn as to whether the soil tested needs phosphorus, potassium, or nitrogen, to produce a good crop. Knowledge of this kind will be of practical value to the farmers of the State, as a guide in the selection of the right kind of fertilizers. This is a practical question that is presenting itself more and more forcibly to our farmers as the difficulty of producing good crops without fertilizers becomes greater.

There are other problems which it is desirable to study in these experiments. For a number of years, chemists have been endeavoring to determine the needs of soils by chemical analysis. The quantity of plant food which can be extracted from the soil by means of a weak solvent is taken as an indication of the quantity that is available to plants. The Experiment Station has been following a method of this kind for many years with a fair degree of success in predicting what kind of fertilizers can be used to advantage, but it is believed that by comparing the results of the pot experiments with the chemical analyses of the same soils, relations may be discovered which will make the results of chemical analyses of more practical value than at present, by enabling the chemist to more accurately interpret their meaning.

The Bureau of Soils of the U. S. Department of Agriculture studies, classifies and maps soils with reference to their physical characters. The Bureau makes what is called a

mechanical analysis, which shows the proportions of clay and sand of various sizes. This gives an idea of the way the soils will behave toward tillage, and a general of the crops for which the soil is suitable. The Bureau does not make chemical analyses of soils, but advocates the making of a special form of pot experiments, conducted in small wire baskets, for testing the manurial requirements. It does not undertake this work extensively, but expects it to be done by the farmers themselves or by others more directly interested than is the Bureau. Consequently, the surveys made by the Bureau, of which we have had several in the State, covering the counties of Union, Warren, Madison, Mason, McCracken and Scott, show the areas covered by the soils of the several types recognized by the Bureau, but they do not indicate whether or not the farmer can use commercial fertilizers with advantage. The work of the State Survey and the Experiment Station will aid in supplying this information.

CHEMICAL AND TECHNOLOGICAL WORK.

Many analyses have been made of coals, ores, clay, stones, waters, etc., but hitherto the volume of chemical work has been much less than was desired, and the amount of technological testing has been small. This has been due not only to the fact that field work has called for so large a proportion of our funds, but to the circumstance that hitherto the Survey has lacked laboratory rooms and appliances of its own. Having no laboratory, it was not possible to employ a chemist who could give his entire time to work for the Survey, hence unavoidable delays in obtaining results have occurred not only with respect to analyses needed by the Survey but also with respect to those asked by citizens throughout the State. Within the last six months, however, the Board of Trustees of State College has provided a mining laboratory building, in which space has been set aside for the Survey; nearly all the necessary chemical and technological equipment has therefore been procured, and a chemist who will give his entire time to the Survey has been employed. The Department of Mining Engineering of State College will cooperate with the Survey in technolgical work, which will prove mutually helpful.

The determination of the heating values of our coals has been begun, numerous samples having been tested during the present year. The importance of this line of investigation will be recognized by those engaged in the coal trade, since the tendency now is to purchase coal for large consumers according to the heat units it yields rather than according to the flat price at which it can be bought. It is planned to also test our coals for weathering qualities and for storage under various conditions.

As stated in the report for 1904-'05, Kentucky is beyond question a great clay State, but it is difficult to interest ceramic industries in strange clays unless the latter have been subjected to various technical tests and the results have proven satisfactory; few established industries are willing to make the tests themselves, hence the Survey has hitherto been at a disadvantage in its efforts to attract the attention of clay workers. We are now, however, prepared to undertake the work and kiln tests will be made of our clays for bricks, pottery, tiles, etc. For this purpose a large Caulkins pottery kiln and a Braun combination kiln have been purchased.

Among the other sorts of technological work planned are: The examination of the explosive qualities of the dust of our various coals; the study of clays for cement, including the availability of the gypseous clays of the Purchase for Keene's cement or for Portland; testing of stone, including crushing strength, weathering, etc.; determination of the crushing strength of our coals, for the benefit of mining operations, in order that intelligent estimates may be made as to the sizes of pillars required for safety; washing and blending coals for coking, a line of investigation that should, if satisfactory results are obtained, prove quite useful in several parts of the Eastern field; the critical examination of Kentucky galenas (lead) for silver, and of manganiferous deposits for cobalt and nickel; separation tests of our zinc and lead ores, of mixtures of fluorspar and calcite, and of fluorspar, calcite and barite; coking tests; and testing of road materials. A thorough testing of our road materials, asphalt, limestone, gravel, clay and Devonian black shales, is a matter of immed-

iate importance. I believe the use of burnt clay may prove the solution of the good roads question of our mountain counties and of other counties where other material may not be readily obtained. The shale beds so abundant in the mountain counties need to be tested as to vitrifying qualities, and as to the best temperature for burning various sorts, the simplest manner that will suffice, and the effect of various percentages of sand, etc. Limestone should be tested for strength, toughness, binding qualities, etc; and the effect of mixing various percentages of petroleum and sand (in a simple way) should be determined for the various sorts.

MISCELLANEOUS MAPS.

During the period covered by this report the following maps have been prepared by Mr. Hoeing: (1) A new geological map of the State, on a scale of 10 miles to the inch, the formations being shown by standard colors. The several geologists of the Survey, including Mr. Hoeing and the writer, have cooperated in outlining the formations shown on the map. On this map the outlines of the coalfields, the more recent formations, the Devonian, the Silurian, and the large divisions of the Ordovician or Lower Silurian (i. e., the Cincinnatian and Mohawkian, the latter including Trenton in its upper part) are outlined with a close approach to accuracy; the lower large division of the Mississippian (Subcarboniferous), i. e., the Keokuk-Waverly, indicated by the deeper shade of blue, however, is not so well outlined, though it is shown more accurately than on preceding maps. It is now known—too late to make the corrections on the map—that in some parts, as in sections of Metcalfe, Green and Taylor counties, the Keokuk-Waverly occupies areas shown on the map as upper Mississippian (light blue); it is also known that there are areas of the Devonian black shale (Ohio black shale of Kentucky reports, "Chattanooga shale" of U. S. Survey reports) at the surface in Adair, and perhaps in adjoining counties, where Koekuk-Waverly is shown. Our lack of accurate knowledge of the outlines of the Keokuk-Waverly was fully appreciated during the preparation of the map, but it was deemed well, in view of the wide and persistent demand for a geo-

logical map of the State, not to defer the preparation of this revised edition until all the details of the Subcarboniferous could be determined. This map has been printed. (2) Map of the upper Cumberland region, to accompany report of Mr. Hodge, showing parts of Harlan, Leslie and Letcher counties, and adjacent territory of Virginia. (3) Map of the Big Sandy Valley region, to accompany the report of Mr. Crandall, including Pike, Johnson, Floyd, Lawrence and Martin counties, and adjacent territory in West Virginia. This has been printed. (4) Map of the Pineville, Log Mountain and Barbourville region, including parts of Knox, Whitley and Bell counties, to accompany report of Mr. Crandall and Mr. Sullivan. (5) Map of the Upper Licking drainage, including Morgan, Magoffin, and Elliott counties, and parts of Carter, Lawrence, Johnson, Breathitt, Wolfe, Menifee and Rowan, to accompany report of Mr. Crandall on the coals of the region. (6) Two maps covering the Conglomerate outcrop on the western border of the Eastern Coalfield, including, in part or in whole, Wayne, Pulaski, Whitley, Laurel, Rockcastle, Jackson, Owsley, Lee, Madison and Estill counties, to accompany report of Mr. Miller. (7) Map including Trigg and Christian counties, to accompany the report of Mr. Fohs. (8) In addition to the larger maps, nearly 500 illustrations (sections, page maps, etc.,) for the various reports that have been prepared. Mr. Hoeing is now preparing an additional map for the report of Mr. Fohs and an additional one for the report of Mr. Miller.

CO-OPERATIVE MAPPING.

The topographic work has been carried on in co-operation with the U. S. Geological Survey, each Survey paying one-half the salaries and field expenses but the expense of publication being borne by the Federal Survey. During the last two years, 2,134 square miles of the area of the State have been completely mapped, making 3,198 square miles completed within four years. In addition, a large amount of primary traverse, for the control of additional areas, has been completed, and in 1906, 126 miles of precise leveling were run. Bad weather seriously interfered with field work in 1906, but

the present year has been especially fruitful of results; during this year 1,345 square miles have been completely mapped, and primary traverse is in progress over the Princeton, St. Charles, Nortonville and Greenville quadrangles, in Caldwell, Hopkins, Christian, Muhlenberg, Todd and Logan counties.

Now seems an opportune time to make a plain statement about the topographic mapping done in the Eastern Coalfield some years ago. Map diagrams which have been issued indicate that the mapping of that field has been completed, but it may as well be stated now that most of the quadrangles that were covered prior to 1900 were very imperfectly mapped, that the published sheets contain many errors, and that revisions must be made. In the beginning of the co-operative topographic work (1904), the published maps were accepted as, in the main, final; but more critical examinations and subsequent experience in the field have disclosed the superficial character of the work, and that the maps with a few exceptions can be considered as no more than reconnoissance sheets, a fact which the U. S. Survey recognizes by now labeling them as such. It is due the present Geographer in charge and due his immediate predecessor to say that the maps were issued prior to their "time," and it is also due the field men of their predecessors to say that more was demanded of them within a limited time than it was possible for them to accomplish accurately. Moreover, it must be distinctly recognized that, though marred by errors, these reconnoissance maps of the Eastern Field have been of exceeding value in the development of that territory; before they were issued there were practically no maps at all of the region.

Nearly three-fourths of the Western Coalfield has been mapped within the last four years; indeed, approximately five-sixths of the total area of good coals has been covered.

Of Rowan and Lewis counties we have less in the way of maps than of any other counties in the State; for some reason they have in the past received little attention. It is planned, with the continuation of the Survey, to have them mapped as speedily as possible, and also to have revisions made of several quadrangles in the Eastern Field.

Necessary primary triangulation has been extended over Breathitt, Floyd, Knott, Letcher, Leslie, Perry, and Pike counties, for control of the Regina, Hazard and Whitesburg quadrangles and eight monuments were set and their positions accurately determined.

Precise Levels were extended through Bourbon, Breathitt, Clark, Fayette, Lee, Powell and Wolfe counties, for control of levels in the Paris, Austerlitz, Winchester, Beattyville, Stanton, and Frenchburg quadrangles.

According to counties, the results of the topographic work of the last four years are as follows:

Anderson, primary control of one-half or two-thirds.
Bullitt, a small part completed and control obtained of more.
Bullitt, a small part completed and control obtained of more.
Caldwell, a small part completed; primary control of the larger part.
Christian, primary traverse of about one-fourth or less.
Crittenden, about one-fourth completed.
Daviess, completed.
Fayette, nearly two-thirds done.
Floyd, primary control of about one-third for revision.
Franklin, about one-half completed, and sufficient control to finish the county.
Grant, control of a small part.
Hancock, a small part completed in addition to that completed hitherto.
Harrison, control of a small part.
Henry, a small part completed.
Henderson, nearly all done.
Hopkins, about three-fourths done and primary traverse of nearly all the remainder.
Jefferson, about three-fourths done, and enough control to complete.
Knott, between two-thirds and three-fourths controlled for revision.
Leslie, a part controlled for revision.
Letcher, a part controlled for revision.
Logan, a small part covered by primary traverse.
Lyon, a small part covered by primary tarverse.
McLean, all done.
Muhlenberg, about four-ninths done and primary control of the remainder.
Nelson, some preliminary work.
Ohio, somewhat more than seven-eighths done.
Oldham, a small part completed.
Owen, not quite one-fourth done; control of about one-fourth more.
Perry, primary control of nearly half for revision.
Pike, primary control of the larger part for revision.

Pulaski, control of part.
Russell, control of part.
Scott, a part done.
Shelby, a small fraction done; control of nearly enough to complete.
Spencer, control of nearly two-thirds.
Todd, primary traverse of about one-eighth.
Union, nearly all done.
Washington, some preliminary work.
Wayne, about one-eighth done, control of about one-third of remainder.
Webster, completed.
Woodford, nearly two-thirds done; sufficient control to complete.

WORK IN PROGRESS OR PROJECTED.

Following is a brief statement of the work in progress and of some of that projected:

1. General account of Kentucky; begun.
2. Study of the salt waters of the State.
3. Examination of spring waters along the Devonian and Silurian outcrops. It is believed that this investigation will develop as a fact that quite pure waters (useful in treating disorders of the stomach) occur along this outcrop, as has been suggested to the writer by Col. J. Stoddard Johnson. The work has been commenced.
4. Examination of certain spring waters (about 20) for rare elements.
5. Location and examination of sands and sandstones fit for moulding and glass.
6. Study of the paint materials of the State.
7. Study of clay deposits continued, including technologic tests.
8. Study of the asphalt deposits: complete it.
9. Study of iron ores; complete it.
10. Continuation of the soil survey, including field work and chemical and pot tests.
11. Revised report on Whitley county.
12. Study of stones resumed, including sandstones for structural purposes, glass making, etc., and limestones for structural purposes, road making, and cement, and for flux, furnace linings, etc.

13. Study of Central Kentucky mineral veins; complete it.

14. Map the disturbances of the State, with reference to oil and gas horizons, and the affect on the amount of available coal; begun.

15. Study of oil and gas horizons continued, especially in the west.

16. Study of the faults in the Western Field, and their effect on the amount of available coal.

17. Study of road materials, including technologic tests.

18. Study of cement and lime materials, continued.

19. Determination of water horizons.

20. Search for peat. Special examination of lignitic deposits with reference to their extent and possible value.

21. Re-examination of the Elliott county dikes.

22. Discrimination of the several divisions of the Subcarboniferous rocks and the economic values peculiar to each.

23. Continue study of the coal deposits.

24. Continue cooperative topographic mapping.

25. Prepare map showing mineral products according to counties.

26. Begin county surveys.

27. Carry on technologic and chemical work as already outlined.

LIST OF REPORTS.

Printed, Ready for Printing, or in Preparation

1. Oil and Gas Horizons. J. B. Hoeing. Printed.

2. Lead and Zinc Bearing Rocks of Central Kentucky. A. M. Miller. Printed.

3. Chemical Bulletin. Dr. Robert Peter, deceased, compiled by Alfred M. Peter. Printed.

4. Coals of the Big Sandy Valley. A. R. Crandall. Printed.

5. Upper Ordovician Rocks of Kentucky. J. M. Nickles. Printed.

6. Clays in Several Parts of Kentucky. J. H. Gardner and Aug. F. Foerste. Printed.

7. Silurian, Devonian and Irvine Formation of East Central Kentucky and their Economic Contents. Aug. F. Foerste. Printed.

8. Report of Progress for 1904 and 1905, including notes on oil and gas; lead, zinc, fluorspar and barite deposits; clays and coals; rock phosphate, etc. C. J. Norwood. Printed.

9. Livingston County; Its Mineral Veins, etc. Based on the report of R. H. Loughridge, with revisions and additions by F. Julius Fohs. Ready for printer.

10. Fluorspar Deposits of Kentucky. F. Julius Fohs. In type.

11. Mining Thin Coals in Southeastern Kentucky. R. H. Barclay. Ready for Printer.

12. Breckenridge and Meade Counties. R. H. Loughridge and J. B. Hoeing. Ready for printer.

13. Coals of the Licking Valley. A. R. Crandall. Ready for Printer.

14. General Report of the Western Kentucky Lead, Zinc and Spar District. F. Julius Fohs. Ready for printer.

14. Coals of the Region Drained by the Three Forks of the Kentucky River. James M. Hodge. Ready for printer.

15. Coals of the Pineville, Log Mountain, and Barbourville Region. A. R. Crandall and G. M. Sullivan. Ready for printer.

16. Coals, etc., of the Conglomerate Measures on the Western Border of the Eastern Coalfield. A. M. Miller. Ready for printer.

17. The Incinnatian Formation and its Economic Values. Aug. F. Foerste. Nearly ready for printer.

18. The Coals of the Poor and Clover Forks of Cumberland River, in Harlan and Letcher Counties. James M. Hodge. Nearly ready for the printer.

19. Key to the State Geological Map. C. J. Norwood. Nearly ready for the printer.

20. **Coals of the Western Coalfield.** C. J. Norwood, aided by S. A. Denney and F. Julius Fohs. Nearly ready for the printer.

21. **Asphalt Deposits of Kentucky.** C. J. Norwood. Nearly ready for the printer.

22. **Iron Ores of Kentucky.** C. J. Norwood. Nearly ready for printer.

23. **Cement and Lime Making Materials of Kentucky.** Begun.

24. **Structural and Other Stones of Kentucky.** Begun.

25. **Coking Coals.** C. J. Norwood. Partly done.

New Geological Map of Kentucky. J. B. Hoeing. Printed.

APPENDIX I.

Abstract of Report on the Lower (or "Conglomerate") Measures Along the Western Border of the Eastern Coalfield.

BY ARTHUR M. MILLER.

Prof. C. J. NORWOOD.

Director, Kentucky State Geological Survey:

Dear Sir: I have the honor to herewith submit a brief abstract of my report on the Lower Measures along the Western Border of the Eastern Coalfield. The field work upon which the report is based was carried on during the summers of 1906 and 1907. Previous to this, extending over a period of fourteen years, excursions had been made from time to time into this territory. I was aided during the summer of 1906 by Mr. L. N. Taylor, of Pulaski county, and most of the references to the coals of that county are based upon his investigations.

Two maps made on the scale of about two miles to the inch have been prepared to accompany the report and are now in the hands of the engraver. A third is in preparation. The two submitted, cover the district from the Tennessee line as far north as 37 degrees and 34 minutes, or about to the southern limits of Madison county. The map in preparation will cover the remainder of the district north as far as 38 degrees, or about to the southern limits of Bath county.

The width of the strip in an east and west direction is determined mainly by the extent of outcrop of the formation known as "The Conglomerate" by some investigators, and as the "Lee," by others. My investigations, however, were not confined exclusively to this formation, but extended in some cases upward into what were once known as the "True Coal Measures," but which in the lower portion are now known as "Breathitt."

The Lee Conglomerate Measures range in thickness from about 900 feet along the western margin near the Tennessee line to about 300 feet at the northern end in Menefee county.

In the southern part of the field, the strata consists of a number of lenses of conglomerate and coarse sandstone interspersed with shales. Prominent among these are the Rockcastle Conglomerate and the Corbin Conglomerate. The former of these is also composed of a number of sub-lenses. North of the Kentucky river the Corbin can not certainly be identified, and the series here falls into two divisions, a conglomerate and a sub-conglomerate member.

In the district somewhat central about Livingston, Rockcastle county, is a conglomerate that cannot be positively identified with the Rockcastle, and is in this report referred to as the "Livingston Conglomerate." It rests down on or close to the Lower Carboniferous Limestone and appears to fill erosion channels in it. The whole conglomerate strip gives rise to very broken country. It is sparsely settled, and roads, other than trails, are few. Where the conglomerate lenses are well developed, the stream gorges are narrow and so filled with boulders that it is scarcely possible to build roads along them. The best roads here are along the crests of the narrow ridges.

The deposits of this region which have economic importance are the coal, the clay, the natural gas, the petroleum and the iron ore. The coal is the most important. In the southern portion there are three seams of coal of sufficient thickness to be workable.

These are in ascending order, the Hudson, the Beaver Creek, and the Barren Fork. I propose for these the numbers One, Two and Three, believing that it is time we should discard the numbering of Owen, which tends to perpetuate the error that the True Coal Measures began at the top of the Conglomerate.*

*The advisability of beginning the numbering of the coals with those that occur in the Lee Conglomerate series is an open question. See foot-note under "Coal No. 1" in Mr. Hodges' summary of the coals of the Three Forks of the Kentucky River, on a succeeding page.—C. J. N.

The No. 1 or Hudson Seam, has its greatest development along the Cumberland river in the vicinity of the mouth of the Rockcastle river, attaining here a maximum thickness of 63 inches of coal separated into two benches by 25 inches of shale. Along the South Fork of the Cumberland, especially in the vicinity of the mouth of the Worley branch, it also attains a considerable thickness, being here 49 to 56 inches thick.

This is the lower of the two coals known more properly as the "Cumberland River Coal" of the early days of Cumberland river coal transportation. In height above the base of the Coal Measures it ranges in the Cumberland river region from 30 to 100 feet.

A tendency to split up into a number of thin seams is a characteristic of this coal, especially in the southern portion of the field. Northward, its distance above the base of the Coal Measures decreases, and a representative of some one of its members is generally found down very close to the Lower Carboniferous Limestone. Sometimes it rests almost directly upon the eroded surface of this limestone.

This is the coal at present mined by the Stearns Company, at the mouth of Worley and Stover branches, on the South Fork of the Cumberland river. It is the lower coal mined at Livingston. It is the coal formerly mined by the Big Hill Coal Co. on the borders of Madison and Jackson counties, and for local use by private parties at numbers of places in Rockcastle and Jackson counties.

It has been opened on Ross creek, just over the line from Estill in Lee county; also on the north side of the Kentucky river on Big Sinking creek. It is worked now in a small way near Dundee, in the Red river drainage, Powell county, and more extensively on Amet's branch of Indian creek in Menefee county. It has also been opened near Scranton, in the Beaver creek drainage, same county. From the former mine, coal is shipped to Mt. Sterling, and from both mines coal is obtained for use on Mountain Narrow Gauge Railroads in the vicinity of which the openings have been made.

In these northern situations the seam, or workable member of the seam, seldom equals or exceeds 24 inches in thickness.

The No. 2, or Beaver Creek Seam.—This also has its greatest developmant in the Cumberland river region, where it was generally known, in the palmy days of Cumberland river mining and transportation, as the "Main" coal. It ranges in thickness in this region from 40 to 51 inches, and is generally about 150 feet above the base of the Coal Measures. Famous mines upon it in the former days were the "Slipup," Huling, Bear Creek, Doolin, Curd and Doyle; and later, the Beaver Creek.

In the South Fork region it was also formerly much worked, and the mine at Bartell, operated by the Stearns Company at the present time, is in a coal at this horizon. It is here 52 inches thick.

North of the Cumberland river, it has been opened and mined for local use at a number of points in Pulaski county; and at Livingston, in Rockcastle county, it is the coal at present mined commercially by the New Livingston Coal Company. It is also the coal formerly mined at Pine Hill, and by the Big Hill Coal Co. on Brush creek.

It is mined at a number of points in Jackson county, as, for instance, in the vicinity of McKee, the county seat, but only for local use.

It attains a considerable development in the Kentucky river drainage in Lee county, where it is known as the Beattyville Coal.

In the vicinity of the town itself, and extending down the river as far as the mouth of Sturgeon creek and up Duck Fork of that stream to the Forks, many openings have been made on this seam. Throughout the whole area where this Beattyville coal is workable the conglomerate member proper seems to be wanting, or is represented by only moderately coarse and massive sandstones.

The horizon of the coal, however, seems to be below that of the main conglomerate cliff in surrounding regions. It attains in this region to a thickness of 38 to 42 inches, though subject to "rolls" which often cause it to pinch out much thinner.

It has an elevation here above the base of the Measures of

about 140 feet. This is as far north as this coal is known to occur.

The No. 3 or Barren Fork Seam.—This seam is scarcely known to occur north of the Cumberland river. It belongs about 200 feet higher up in the series than No. 2, or about 350 feet above the base of the Measures. It ranges in thickness from 32 to 36 inches. It is the coal mined along the Cincinnati Southern railroad from Cumberland Falls Station to Barren Fork Station.

The Breathitt Formation is characterized by a predominance of shale over massive sandstones and gives rise to a much more level country than does the Lee.

The deposition of these shales was ushered in by an epoch of coal making almost as extensive as that which characterized the begining of the Coal Measure Time itself.

The No. 4 Seam (the Lily, or Laurel Coal).—This coal, (No. 1 of the older authors), can be traced in almost continuous outcrop practically across the State from Tennessee to Ohio.

It is the coal mined on the Cincinnati Southern railroad just south of Pine Knot, in the vicinity of Strunks Lane, where it is about 28 inches thick and down very close to the top of the Corbin. From here it can be traced, by openings made on it for local use, along the base of "Jellico Mountain," following the sinuosities made by the Marsh and Jellico creeks and their tributaries, reaching in some cases as far as to and beyond the Tennessee line, all the way to Williamsburg on the Cumberland river, where it has been mined 30 inches thick and not over ten feet above the top of the Corbin. The latter has here lost its conglomerate character and is a shaly sandstone.

From here it may be traced up the Clear Fork of the Cumberland to a point about half way between Pleasant View and Saxton.

North of the Cumberland it may be traced in the drainage of Watts creek, close to creek level as far as Rockhold, and has been mined mainly for local use in this stretch.

At Rockhold it passes beneath drainage and nothing more

is seen of it along the line of railroad until the vicinity of Lily, Laurel county is reached. It here rises above drainage again, is 36 to 42 inches thick, and not over 20 feet above the top of the Corbin. The name "Lily" is given it from its typical occurrence in this locality. It is extensively mined here. It again passes below drainage along the line of the railroad and is a short distance below at London, county seat of Laurel county. North of London, it reappears at Pittsburg (36 inches thick and 20 feet above top of Corbin), and may be traced from there in continuous outcrop to East Bernstadt and Altamont, in the vicinity of which two stations it is 37 to 49 inches thick. Here the outcrop line leaves the railroad and may be traced in the drainage of Little and Big Raccoon creeks almost to the Rockcastle river.

The coal is not well developed in Jackson county, but it is seen in the bed of Laurel Fork of Rockcastle river above Moore's Mill, from which it has been raised for local use by stripping.

Passing over into the drainage of Sturgeon creek, some traces of this coal are seen on top of the Conglomerate towards the headwaters of this creek and on some of the tributaries, as, for instance, Travis creek, but it is of no economic importance here.

Lower down on Sturgeon and especially on headwaters of Duck Fork in Owsley county confines of Lee, it begins to assume more importance; but is still mined only for neighborhood use. It still bears its same relation to the top of the Conglomerate. One other opening is seen on this coal—that by the side of the road on the ridge between Pebworth and Beattyville, and then the Kentucky river is reached. The hills in the vicinity of the river are not high enough to catch this coal here, but in the elevated region in the neighborhood of Zachariah P. O., confines of Lee and Wolfe county, there is a coal at this horizon that has been mined for neighborhood use. It is about 36 inches thick here.

Some traces of this coal are seen in that portion of Lee county which lies between the Middle and North Forks of the Kentucky river, but it assumes no importance there. It obtains a greater development in Wolfe county, where in the

drainage of Upper Devil creek it has been rather extensively opened. It is liable here to be badly split up by partings. The coal may average 36 inches in thickness. It is down very close to the Conglomerate.

North of Campton no trace of this coal was found by the writer, though there are extensive ridge areas in northern Wolfe and Menefee counties where the horizon of coal is due.

The No. 5 or Bacon Creek Seam (Lower Blue Gem).—This seam, named from a tributary of Lynn Camp creek in the vicinity of Corbin, along which it has been rather extensively worked for the Corbin market, is quite persistent in the southern portion of the field. It is never very thick in this region, reaching a maximum of not over 27 inches. In the region south of the Cumberland river it is known as the "Lower Blue Gem." In all this district its position is from 150 to 160 above the Lily Coal, or 170 to 180 feet above the top of the Corbin. Possibly the upper coal, 125 feet above No. 4 in Wolfe county, is this seam. It is here 36 to 40 inches thick and badly split up by partings.

The No. 6 or Upper Blue Gem.—The position of this coal is 225 to 240 feet above the top of the Corbin.

The last two coals are not of any importance south of the Cumberland river except where they can be mined in the same hill along with the next seam above them in the series, namely:

The No. 7 or the Jellico Seam.—This is the main seam throughout a large district in eastern Whitley county.

It belongs to that portion of the Breathitt which tends to become mountainous, so it is usually found a considerable distance above drainage. It ranges in thickness from 30 to 62 inches and is commonly separated into two parts by a parting near the middle.

Its position in the series is from 260 to 300 feet above the top of the Corbin, in all that portion of the area where a steep section from top of the Corbin to the coal could be found.

In the vicinity of Jellico itself, where the Corbin is below drainage, the interval seems to be much greater.

This thickening is in accordance with what we should expect as the Pine Mountain is approached. We know there

is an enormous thickening of all the Measures in the vicinity of this mountain range.

The Jellico Coal has been fully described by Prof. Crandall in his report on Whitley county, published by the Survey during the administration of the late John R. Procter. North of the Cumberland river this seam may be traced in the mountain east of Watts creek and the Louisville & Nashville railroads as far as Rockhold, where its line of outcrop leaves the railroad and trends to the eastward into Clay county.

My investigation did not permit of its being followed further in this direction, but at the headwaters of Sturgeon, Sexton, and Island creeks, where Jackson, Owsley and Clay counties join, a coal was noted which had about the position of this seam and is provisionally correlated with it.

A coal was also noted at the top of the high ridges, heads of Lineman, Pappaw, and Buffalo creeks, confines of Owsley, Lee and Breathitt counties, which may be at the horizon of the Jellico. It ranges here somewhere in the neighborhood of 48 inches thick.

Clays were noted in various parts of the field. Those in the vicinity of Pine Hill, in Rockcastle county, have been tested and found to possess some commercial value, and some have been shipped.

The opportunity for finding valuable fireclay at the base of the Coal Measures will increase as the margin of the field is traced northward, for its development seems to be correlated with the development of an uncomformity which increases in amount northward.

Iron Ore occurs at the base of the Coal Measures near the tops of the ridges, from the headwaters of Slate and Beaver creeks, tributaries of Licking, to the Kentucky river. It occurs just on the top of the Lower Carboniferous Limestone; is of excellent quality, though low grade as regards iron content; was the main basis of the iron industry in Kentucky at a period of industrial development when she ranked "fourth" State in the production of iron in this country; and may again be worked when conditions more favorable to smelting of low grade ores occur again, as they probably will.

Natural Gas.—The supplies of gas which are piped to Mt. Sterling, Winchester and Lexington, come from some 43 wells drilled on Leatherwood and other forks of Indian creek, on Spaas creek, Short creek, and Right Fork of Cane creek, all tributaries of Red river, and on Hawkins branch and Petre Trace branch of Slate creek. Some of these wells are in Menefee and some in Powell county. They all start, so far as I was able to observe, in the Waverly formation, and strike the gas in the magnesian limestones which closely follow in descending order the Black Shale.

Oil.—The oil of the Irvine field, obtained from shallow wells along the Kentucky river at the mouth of Cow creek, also comes from about the same horizon as the Menefee gas. The wells start in the Black Shale.

Very respectfully,

ARTHUR M. MILLER.

APPENDIX II.

Summary of Report on the Region Drained by the Three Forks of the Kentucky River.

BY JAMES M. HODGE.

The drainage area of the Three Forks of the Kentucky river, in the southeastern part of Kentucky, includes the whole of Breathitt, Perry and Leslie counties, the greater parts of Lee, Knott, Letcher and Owsley counties, and small parts of Wolfe, Harlan Jackson, Knox and Bell counties; in all about 2,800 square miles or nearly 1,800,000 acres.

The whole region is occupied by narrow crooked valleys or ravines and steep hillsides terminating in narrow, serrated ridges as tortuous as the valleys. The fall of the larger streams is exceedingly slight, Hazard in Perry county and Hyden in Leslie marking approximately the heads of navigation on the North and Middle Forks. To a large degree, the fall of all the streams increases in proportion as their volume diminishes. Such branches everywhere are torrential, but the rise three miles from the head of any stream rarely exceeds 150 feet per mile. The hills, ordinarily 200 to 400 feet high about the junction of the forks and west of South Fork, increase in average height in going up stream until the maximum is reached in Pine Mountain and Kentucky Ridge, at the heads of the forks, each about 1,000 feet above the main drainage. The extremes above sea level are at Beattyville, at the mouth of South Fork, elevation 640, and the top of Pine Mountain, elevation about 2,800.

Valleys and hillsides all were originally covered with a heavy growth of fine timber, but most of the lighter woods, poplar principally, have been floated to market. Of the heavier woods, black walnut is practically gone, and a

beginning has been made in marketing white oak, especially in the northern part of the region.

Farms have been cleared along the valleys almost continuously on all but the smallest streams, and the clearings extend well up the hillsides, not infrequently to their tops. After a few years of cultivation the rich soil of the steep hillsides is washed off, the fields are abandoned and new ones cleared. Occasional broad benches high on the hills give farms of easier slope, unseen from the roads along the main streams. Notwithstanding all this, there remains on the waters of the North and Middle Forks an immense area, more than half the acreage probably, rich in hardwood timbers, and with a considerable quantity of valuable soft woods. On the South Fork the proportion of timber land is less, perhaps one-third the average.

The geological range of the region is from the Subcarboniferous limestone (and associated sandstones and shales) at river level at Beattyville up some 1,500 feet* into the Coal Measures, as shown in outcrop along the river up to the top of Kentucky Ridge.

The Coal Measures extend unbroken up against the northern face of Pine Mountain, but the face gives an exposure of Devonian rocks at the base of the mountain up to the Lower Conglomerate at its top. The uplifting of this mountain resulted in a fault of over 1,000 feet, and broke the continuity of the coalfield, which otherwise would have extended without interruption southward into Virginia. Strata dip in this mountain southeast, generally nearly coincident with its southern face, but often at a much greater pitch.

Elsewhere throughout the region, with little exception, the dip is toward the center of a basin about a mile south of Jackson, Breathitt county. The chief exception is found south of Manchester, Clay county, where a slight southward dip obtains. The average rate of dip nowhere exceeds 1 per cent.

*No attempt has been made to determine this with accuracy.

and the maximum rate is probably below 3 per cent. except in such sharp flexures, or local rolls, as are common to all nearly level coal regions.

There are in this region about twenty distinct beds of coal, of which over half are of workable thickness, varying from three feet of clean coal up to over nine feet without parting, though all beds are apt to be more or less injured by partings. Cannel coal appears in at least eight beds, and some of them with considerable persistence.

Following are traced in brief outline the principal deposits of coal so far discovered.

Beattyville Coal Bed.—The lowest coal of the region is that mined at Beattyville during the last forty-five years, more or less, and more recently along the river above and below Beattyville. It lies near the base of the Lower Conglomerate measures, about 30 feet above the river at Beattyville, and, but for the insignificant area there cut out by the river, and Pine Mountain, it underlies the whole region. Where mined near Beattyville it has been found generally 3 to 5 feet thick, but it sometimes runs below workable limit.

It sinks below drainage at St. Helens, at the junction of North and Middle Forks, and farther up these streams its depth below them is governed not only by their fall and the dip of strata, but largely by the increase in thickness of Conglomerate measures overlying the coal.

While this would probably result in carrying the coal within a few miles up those two forks to a depth prohibitive of mining for many years to come, the case differs on the South Fork. There the strata rise with the stream, and there is reason to believe that the bed may be found of workable thickness at moderate depth below drainage as far up as Manchester and perhaps beyond.

This coal stands well in the market as a steam and domestic coal, after long use especially in Richmond and other towns of Central Kentucky.

Rockhouse Coal Bed; Manchester Coal; "Coal No. 1."*—This bed is in this region the first above the Conglomerate Measures. It is below drainage throughout most of the region, but has outcrops near the bases of hills in Wolfe, Lee, Letcher, Owsley and Clay counties. In the first two it is worked for some extent for local use though rarely more than three feet thick and generally less. In Letcher, above and below Whitesburg, it runs from 3 to 5 feet in thickness of coal, and is nearly uniform, at 3½ to 4 feet clean, on Upper Rockhouse creek.

In Clay county it is largely used for local needs, especially in the vicinity of Manchester, where it runs 3 to 4 feet thick without parting. It supplied fuel for many years to the salt works operated on Goose creek.

As in Northeastern Kentucky, the coal seems to be remarkably pure, and especially as regards sulphur. The quality of coal is perhaps more uniform in this bed than in any other of the series.

River Hill Coal Bed; Elkhorn Coal; Coal No. 3.—This bed, lying 150 feet to 200 feet above the preceding, known as the River Hill Coal in the vicinity of Jackson, was mined there in earlier times and transported to Central Kentucky by boats and rafts. Operations upon it were renewed with the introduction of railroad carriage. From the mouth of Quicksand creek, where the bed is at river level, northward through Wolfe county, where the bed is near the tops of the hills, it varies in thickness of coal from 2½ to 3½ feet, with a parting of from 2 to 12 inches.

With some doubt as to correlation, it is probably the same as the Elkhorn bed which, rising above drainage on Carr fork at the mouth of Defeated creek, with about 3½ feet of coal there, carries 8 feet or more of coal, with slight parting, over onto Elkhorn creek, Pike county.

In Letcher county, below Whitesburg and on the South Fork, so far as known, the coal is thin.

The great value of the Elkhorn coal for coking has been made known by much investigation since the discovery of its coking property by a member of the State Survey in 1883. This, combined with the great thickness and excellent quality of the coal, makes the field probably the most important in the state. While the River Hill coal will make coke it does not yet appear that it is particularly well adapted to that purpose.

Fifty to eighty feet below the Elkhorn coal, in the Upper North Fork region, is a bed of clean coal 3 to 4 feet thick of considerable value in that region. Elsewhere it appears to be thin, except possibly in pockets on the Middle Fork.

Whitesburg Coal Bed.—This bed, like the preceding, has been found of workable thickness in a relatively small area only in the vicinity of Whitesburg, where it ranges from 3 to 5 feet thick, without parting. It is not unlikely that its further exploitation may develop additional areas of value, but over much of the region it is too much cut up with partings or is thin. It is mined opposite Whitesburg, yielding much splint coal, and all of excellent quality for the domestic use which it serves. Its roof is usually black slate.

Hyden Coal Bed; Sisemore Coal Bed; Fireclay Coal Bed; Coal No. 4.—This bed is the best known bed of the region, owing in part to its thick coal at convenient height in many places, and in part to its commonly carrying a flint fireclay parting by which it is readily identified. The bed lies about 60 feet above the preceding and 300 feet above the Elkhorn bed.

First seen with characteristic parting on North Fork waters, on Lost creek and 30 feet high at the mouth of Cockerel fork, it has there but 3 feet of coal, the parting injuring it seriously. Near the mouth of Lots creek, and on the river below, it is 3 to 4 feet thick, without parting or with parting inconsequent. A few miles up Lots creek it changes to cannel coal before going below drainage.

From Lots creek up the river to Sasafras creek, Carr fork, it ranges from over 3 feet to over 4½ feet of coal, rising from 50 feet above the river to 150 feet above Carr fork.

From Sasafras creek westward to the heads of Rockhouse and Millstone the bed carries 3½ to 5½ feet of coal, sometimes in part a fine cannel. On millstone it lies 400 feet above the creek. On the west side of the North Fork the 5 to 5½ feet coal of Lick branch (above Lost creek); the 20 inches of coal on 14 inches of cannel of Georges creek; and the 88-inch coal of Wolf creek, all without parting, and the 5-foot coal of Long's creek, are referred with some question to this bed.

On Mace's and Leatherwood creeks and Line fork the bed has usually 3 to 3½ feet of coal, with parting on Line fork forming its floor and 3 feet of coal above it. Near the head of this fork it is below drainage.

On Cutshin creek and on Middle fork and its waters above Cutshin the bed has generally 3 to 3½ feet of workable coal. At Hyden, where it is called the Sisemore coal, the bed is about 5½ feet thick including the 7-inch fireclay parting. The coal is lowered 200 feet from the mine on an incline ending on the main street of the town.

On Red Bird creek it has 4 to 3 feet of coal, but where thickest one or two thin partings appear in addition to the usual fireclay.

Too high in the hills to be of much value on Goose creek except near the head, it is there (with some uncertainty as to correlation) over 4 feet thick without parting. In quality the coal is quite uncertain, though generally good for steam or domestic use and sometimes particularly fine. It is usually in part splint coal, and sometimes part cannel. On Lots creek, Breathitt county, and again on Greasy creek, Leslie county, it has been found wholly cannel.

Rider to Fireclay Coal.—This bed is chiefly important because of its proximity to the bed just described. Though sometimes absent, it is often found 5 to 20 feet above the Fireclay coal, especially in Leslie county, and there, on Beech fork, has 38 inches, solid, of cannel coal. It is also workable on Lots creek, Perry county.

Haddix Coal Bed.—This bed, so far as yet known, has comparatively little workable area. At the mouth of Troublesome creek, above Jackson, it has 4 feet of exceptionally fine

cannel. In the high ridge between lower Troublesome and South Quicksand creek it has nearly 5 feet of coal, and on Lost creek it appears to range from 3½ feet near the mouth to 4 feet at the head, though perhaps under 3 feet in places. Beyond the ridges about Lost creek the coal, where identified, is either thin or badly separated by partings. It is a difficult bed to find, and is less known than those below it.

Owing to its remarkable purity and to its carrying cannel or semi-cannel coal through a large part of its area, and because of its nearness to railroad, it is likely to find early development and favor in the market. It was well known in Central Kentucky before railroads superseded transportation down the river.

Hazard Bed.—This bed is one of the most regular of the region and may be counted upon generally to carry about 5 feet of coal, but as it lies about 300 feet above the Fireclay coal its area is considerably restricted.

Flint ridge, between South Quicksand and lowed Troublesome creeks, contains a working area of it farthest north, Southward, in Breathitt county, it has workable areas mostly well up in the main ridges. Toward the head of Lost creek and near drainage level it has over 7 feet of coal, and on the head of Long or Trace fork of Buckhorn, also low in the hill, it has 100 inches, its maximum thickness probably.

The principal openings in Knott county are at the mouth of Dans fork of Buckhorn, 7 miles above Long fork, coal nearly 5 feet, and near Hindman, coal 3½ feet. At the latter place an aerial tramway delivers the coal into the valley from a height above the creek about 460 feet, but correlation is not fully determined.

In the northern half of Knott county but little exploration has been attempted, and in the southern half the bed is too high to have created much interest. In most of Letcher county its place is above the tops of the hills.

In Perry county the coal ranges from 4 to 5 feet thick with workable areas in all the principal ridges, and a large field of the coal about the heads of Leatherwood creek.

Along the eastern side of Leslie county the coal has been found 4 to 5½ feet thick, the latter including 23 inches of cannel

coal on Laurel fork of Cutshin creek. Elsewhere on Middle Fork waters the bed is more or less broken up with partings, or the little search made for it has failed to show its better condition.

On Sugar creek, a branch of Red river, in Leslie county, the coal is 7 feet thick, but too high in the hill to be of present value. It gives ample areas southwards.

The coal seems to be fairly uniform in quality, with some appearance of being fit for coking, though sometimes carrying too much splint coal. It is generally a clean coal with little or no partings, and finds favor where used locally.

Flag Coal Bed.—This bed takes its name from the plates of cannel coal resembling flag-stones exuded from the outcrops about the mouth of Troublesome creek. But little is known of the bed elsewhere than in southern Breathitt county. It is 30 to 80 feet above the Hazard bed.

On lower Lost and Troublesome creeks it is about 3½ feet, thick with a tendency to cannel coal in the bottom seam. On the head of Trace fork of Buckhorn creek it has 5 feet of coal. On the head of Irishman creek, what appears to be the same bed has 5 feet of nearly clean, bright coal, largely splint. And again on Mace's creek near its mouth nearly the same section. On the head of Leatherwood creek, Perry county, what is probably the same bed gives 3½ feet coal.

The coal seems to make an excellent fuel, and the cannel, where it occurs, is particularly fine.

The Hindman Coal Bed.—This bed is given its name bebecause of its great thickness, over 9½ feet of coal apparently without parting, near the town of that name, and on the Right Fork of Troublesome creek. The bed is here about 500 feet above the Fireclay bed, too near the top of the hill to be of value. On the divide between Big and Mace's creeks it shows a thick stain and probable working area. On Cutshin creek, near Hyden, it has 6 feet of coal near the top of a high peak.

Above Hyden there are good workable areas of the coal, with 7 feet thickness (correlation somewhat doubtful) on White Oak, a branch of Greasy creek, and about 5 feet on

Oldhouse and Reuben branches of Beech fork. There should be a large area of the coal in Kentucky Ridge and its extension along upper Line fork.

The coal appears to be well adapted to coke-making.

There are probably higher workable coals in Kentucky Ridge, but they have not been investigated far enough to find place here.

On the following page are some representative analyses of the coal of the principal beds sampled, for the State Survey, through the whole working sections of the coal seams; and also some Elkhorn coal and coke analyses (without laboratory number) reported to the Survey.

In this area of 2,800 square miles there is but little which is not underlaid by a workable coal bed; two such beds are not uncommon, one over the other; and three containing 12 to 15 feet of coal may be found, with additional possibilities not yet developed. But, as yet, railroad entrance into the field is barely accomplished, by the Louisville & Atlantic touching it at Beattyville, and by the Lexington & Eastern Railway reaching only to Jackson, with a connecting link between the two.

Upon these roads the main dependence for the development of the lower part of the region appears to rest, and an extension of the Lexington & Eastern up Lost creek appears to be imminent, with ultimate extension via Carr creek to the head-waters of the river. These, however, can be reached more readily from the railroad now built up Big Sandy river, and a through connection is likely to be accomplished early in the general development of the region.

From such a line the North Fork region can be pretty well covered by branch lines along the numerous streams, which can be followed without serious hindrance.

The Middle Fork can best be developed by railroad from the north, though a cross-country line from the west is practicable, and entrance from the southwest via Straight creek is proposed.

The South Fork will probably be developed by railroad from the southwest conjointly, movements from both directions, for short distances only, being now in progress.

Pine Mountain presents a barrier to access from the south-

east which may be overcome only when other means prove insufficient.

A detailed report for the State Survey of that part of this region farther south than the mouth of Quicksand creek has been prepared by the present writer.

JAMES M. HODGE.

ANALYSES TO ACCOMPANY

Labor'y No.	Name of Bed.	Location.	County.	Total Coal. Inches.
2708	Beattyville	Sturgeon Cr.	Lee	47
2704	Beattyville	Sturgeon Cr.	Lee	84
2357	Rockhouse	Rockhouse Cr.	Letcher	44
2358	Rockhouse	Mouth of Sand Lick Cr.	Letcher	25‡
2359	Rockhouse	Mouth of Sand Lick Cr.	Letcher	28†
2649	Manchester	Goose Cr.	Clay	89
2756	Elkhorn	Mo. of Little Carr	Knott	46
2352	Elkhorn	Laurel Br. North Fork	Letcher	96
2361	Elkhorn	Same opening; Lower seam	Letcher	70
------	Elkhorn	Potters Fork	Letcher	88
------	Elkhorn	Same, 48-hr. Coke	Letcher	------
------	Elkhorn	Same, 72-hr. Coke	Letcher	------
2528	Fireclay Coal	Lost Cr.	Breathitt	24
2754	Fireclay Coal	Rockhouse Cr.	Letcher	c. c. 18
2753	Fireclay Coal	Millstone Cr.	Letcher	66
2737	Fireclay Coal	Rockhouse Cr.	Leslie	69
2735	Fireclay Coal	Greasy Cr.	Leslie	44
2647	Fireclay Coal	Indian Grave Br.	Clay	51
2739	Rider to Fireclay Coal	Beech Fork	Leslie	c. c. 88
2282	Haddix	Mo. Troublesome Cr.	Breathitt	c. c.
2530	Haddix	Russell Br.	Breathitt	58
2795	Haddix	Mo. Squabble Cr.	Perry	86
2735	Hazard	Mo. Dan Fork	Knott	58
2755	Hazard	Hindman	Knott	42
2738	Hazard*	Laurel Fk. Cutshin	Leslie	67
2737	Hazard	Laurel Fk. Cutshin	Leslie	c. c. 23
2733	Flag	15 Mile Cr.	Perry	86
2732	Flag	16 Mile Cr.	Perry	58

‡Upper seam. †Lower seam. *Analysis of bituminous portion.

REPORT OF JAMES M. HODGE.

ANALYSIS.

Specific Gravity.	Moisture.	Volatile Comb. Matter.	Fixed Carbon.	Ash.	Sulphur.	Character of Coke.
1.345	4.16	38.97	49.24	7.68	1.97	Spongy
1.229	3.53	40.51	49.00	6.96	2.60	Spongy
1.242	1.46	35.84	58.60	4.10	1.068	Light Spongy
1.277	1.30	39.60	55.20	3.90	2.812	Light Spongy
1.286	1.60	36.40	56.60	5.40	1.060	Light Spongy
1.278	1.48	35.92	54.70	7.90	0.885	Spongy
1.367	2.92	34.90	54.36	7.82	0.65	Friable
1.291	3.26	32.24	61.60	2.90	0.656	Dense
1.319	2.86	31.54	62.10	3.50	0.585	Dense
----------	1.950	37.350	57.367	2.800	0.533	----------
----------	0.302	1.623	91.320	6.165	0.590	----------
----------	0.170	1.135	91.731	6.505	0.459	----------
1.366	1.40	35.90	52.50	10.20	3.483	Spongy
1.309	0.39	46.11	40.50	13.00	2.00	Dense
1.333	1.43	37.00	53.35	8.22	0.71	Spongy
1.279	0.74	36.06	54.00	9.20	1.307	Spongy
1.251	1.72	35.02	57.60	5.66	0.599	Spongy
1.288	1.10	35.60	56.90	6.40	0.885	Light Spongy
----------	1.10	44.20	43.70	11.00	0.690	Dense
1.212	1.60	46.60	46.80	5.00	0.824	Dense Spongy
1.345	3.80	35.60	54.80	5.80	0.875	Dense
2.257	1.90	37.10	57.90	3.10	0.749	Spongy
1.294	1.76	41.98	49.67	6.59	1.83	Dense Spongy
1.264	1.44	41.67	52.24	4.65	1.05	Spongy
1.290	1.67	38.78	53.91	5.64	1.84	Dense Spongy
1.225	1.56	46.94	45.16	6.34	0.72	Dense
1.337	2.48	35.51	52.43	9.58	1.05	Dense Spongy
1.299	2.09	38.61	54.21	5.09	0.83	Dense Spongy

APPENDIX III.

Abstract from Preliminary Report on the Field Work of the Soil Survey.

BY AUG. F. FOERSTE.

During the summer of 1907 a general survey of the soils of the Mississippian or Subcarboniferous areas of the western half of Kentucky was undertaken by the Kentucky Geological Survey. This work was placed in charge of Mr. Aug. F. Foerste, and he was very efficiently assisted by Mr. George F. Brockman and Mr. Graham Edgar.

The field work consisted in a careful collection of samples of soil over as wide an area as it was possible to cover in the time at disposal. Since it was not possible to cover the entire field thoroughly, a number of representative counties were studied in considerable detail, and the remainder were examined sufficiently to determine at least the most important characteristics of their soils. With the continuance of the Survey, the work will be extended until all of the counties of the State have been covered.

During this preliminary investigation, the soils along the river and creek bottoms were excluded, since they represent the richest soils of the State and are highly productive under almost any system of cultivation. Here, soils resulting from the decay of many kinds of rocks have been commingled by wash during high waters, and the resulting mixture almost invariably contains every element necessary for plant growth.

The soils above the reach of high waters, on the contrary, have been formed by the decay of such rocks as happened to be exposed to the air within recent periods, geologically, there where the soils now are found. Along hillsides, where several kinds of rocks are exposed, the different soils formed by their decay may be washed by rains to lower levels, and more

or less commingled along the lower slopes of the hills and on the immediately adjoining fields.

Along the more level fields, however, where the overwash due to rains is less considerable, the soils usually represent the materials which remain after the decay of the rocks of the immediate vicinity. For instance, a sandy soil indicates the former presence of a layer of sandstone, and a deep red clay soil in this part of the State usually indicates the former presence of a limestone.

It rarely is difficult to determine from what kind of rock any soil has been formed. If the original source of the soil was a layer of rock of any considerable thickness, usually enough of the rock remains, notwithstanding the decay of a great part of the same, to indicate the nature of the source. This is especially true of the lower part of the layer, since decay usually is greater near the surface of the earth, the lower parts of a layer of rock frequently being still quite fresh, while the upper and middle parts already have disintegrated into soil.

It is quite evident that if soils result from the decay of rocks, the chemical characteristics of soils are dependent largely upon the chemical constituents of the rocks from which they were formed. Moreover, where larger layers of rocks of considerable thickness may be traced for many miles across the country, similar soils may be expected to result from the decay of similar rocks. Therefore, it should be possible to secure an approximate idea of the characteristics of the soils of a county from a knowledge of the underlying rocks.

For this reason, the Survey has undertaken a study of the soils of the Mississippian or Subcarboniferous areas of Western Kentucky, and has attempted to show how the nature of these soils varies with the nature of the rocks from which the soils were derived.

The most obvious study of a soil consists of an investigation of its chemical characteristics. Investigations of this nature have been conducted by this and by former surveys of the State, but not in the systematic manner which it is hoped to inaugurate in all future work, especially in relation to the

connection between the characteristics of soils and the rocks from which they have been derived.

The fertility of a soil, however, depends not only on its chemical constituents but also upon its physical characteristics, whether the grain of the soil be coarse or fine, porous or rather impervious to rain, especially when more or less parched during a long drought. The capacity of a soil, not merely to take water, but to hold water in sufficient quantity, determines its availability for different crops. For this reason the physical study of a soil is as important as its chemical study, and it is intended to give this part of the subject also proper consideration.

The field study of soils consists in noting the different qualities of soils found in the different counties, and in determining from what geological formations these soils have been derived. As far as possible, the information already gathered by farmers and other practical men is sought and recorded.

The field study of a soil should contain at least the following information:

The exact location of every sample of soil studied. It should be possible, from the record, to determine not only the field, but the corner of the field from which the sample was collected, even in case that fence lines are changed, so that the study of the soil should have value not merely for one or two years, but for a much longer time.

On sloping hill surfaces, the elevation at which soil was collected, above creek or road level, often will assist in locating the exact spot from which the soil was obtained.

The number of points from which cores were taken in order to make up the sample should be designated, since, the greater the number of cores and the more these are scattered over the corner of the field selected for investigation, the better the sample will serve in giving the characteristics of the average soils from this locality. The method of sampling used will be described later.

It is a good idea to state by whom and when the soil was collected, since different treatments of soil may either enrich or impoverish the same, and a record of the date will give an idea as to the rate at which these changes are taking place,

in case future investigations of the same territory ever should be considered desirable. Even the time of the year and the condition of the field would add desirable information, since the quantity of soil entering the soil tube would be modified by condition of the field at the time of sampling, whether recently plowed, as in the case of a tobacco field, or long at rest, as in the case of a wheat or oat field after harvest. In the case of pasture land, long idle, the quantity of soil entering the soil tube would be much greater than in the case of a recently cultivated corn field.

The situation of the sampled soil, whether upon upland, or down in the valley, along hillsides, or in flat level fields, near stream courses, or far above the highest waters, should be noted, since this would indicate to what extent the soil would be liable to mixture with other soils from sources farther up the stream or hillside. Moreover, the amount of moisture which will enter a soil is determined to a considerable extent by the location of the field of which it is a part.

Of course, all physical characteristics of the soil which it is possible to discover by examination in the field should be recorded. This can often be done very readily, especially where the soil has been cultivated recently, but a considerable part of the physical examination of soils can be conducted more conveniently in the laboratory of the Survey, to which samples collected are sent.

The trees characteristic of the lands from which the soils have been collected often are an index of the value of the soils for different crops, and their presence or former presence should be recorded. Such information can often be secured from the farmers who have long lived in the neighborhood.

The best crops so far produced by the field, those for which the field appears best adapted and the average yield of the field during an average season are items which can be learned best from the farmer, but a certain skill in estimating the average yield of a field may be secured by examining the condition of the crops of this or adjoining fields, and this information should be used as a check in determining the reliability of the various reports received, in the few cases where such a check is desirable.

The extent to which fertilizers have been applied in the past should be noted, the different fertilizers used and their relative value for different crops should be recorded. In many cases, farmers who deny using fertilizers will be found using stable manure, not classing this under the name of fertilizers. There is much curious information current among certain farmers, which it is desirable to secure, in order that the reliability of this information may be tested by scientific methods. Many farmers believe that certain fertilizers may be advantageous in wet weather but positively harmful during a dry season. Others think that fertilizers are of value for one or two seasons and then leave the fields in worse condition than ever before. The basis upon which these conclusions have been reached should be ascertained and tested.

The length of time during which the soil tested has been under cultivation should be learned, since virgin soils contain considerable humus making the soil very fertile during the earlier years of its cultivation, and a comparison of virgin soils and old soils from the same immediate vicinity would serve to indicate some of the changes which may be expected in the future and might lead to suggestions as to methods of cultivation or of fertilization which would assist in either maintaining or improving the value of the soil studied.

It has been evident to the party, while in the field, that farmers are willing to welcome a practical study of their soils. Many expressed regret that in the short time at the disposal of the men, the soils belonging to their own fields could not be selected for study. But it was also quite evident that what these farmers wanted was not merely theoretical assistance, but practical assistance, such as a farmer could use in improving the productiveness of his soil. It is the intention of the Survey to provide such information.

The sampling of soil is done by means of a sampling tube. This consists of a steel tube, about an inch and a half in diameter, but with thin walls, similar to the thin walled tubes used for bicycles. Into the lower end of this tube is inserted a short piece of tubing with a smaller interior diameter, so that anything passing through the short piece of tubing at the

bottom of the sampling tube would lie rather loose within the walls of the sampling tube itself, and therefore would drop out of the upper end of the sampling tube if the latter were inverted. The short piece of tubing at the bottom of the sampling tube is filed on the outer margin so as to produce a sharp cutting edge at the bottom, thus making the driving of the tube in the ground a comparatively easy operation. The upper end of the sampling tube is inserted into a heavier piece of tubing so as not to suffer as much from the heavy blows of the mallet by means of which the tube is driven into the ground. This mallet consists of a massive piece of iron into the ends of which comparatively large pieces of wood may be inserted, this wood damaging the upper end of the sampling tube less than would the direct blows of an iron mallet. Provision is made also for the insertion of the wooden handle belonging to the mallet.

A part of the field having been selected for sampling, the cutting edge of the sampling tube is placed on the ground and the tube is driven into the soil, by means of the mallet, usually for a distance of six inches. Owing to a mark filed into the outer surface of the sampling tube, it may be readily determined when the tube has reached the proper depth. On drawing out the tube, the soil which has entered the tube does not drop out, being held sufficiently by that part of the soil which is held by the short cutting edge of the tubing inserted into the bottom of the sampling tube. On inverting the sample tube, however, most of the soil drops out, and the little which remains behind at the cutting edge may be readily pushed into the main body of the tube.

All of the soil secured as the result of driving the tube once into the ground is called a core. Such a core has a diameter of nearly an inch and a half, and a length of fully six inches. Walking a distance of about thirty feet, the tube is driven into the ground again, and a second core is secured. Usually 12 cores are taken, each 6 inches long, from different parts of the field, being careful not to commingle different kinds of soil, and all 12 cores are dumped into the same bag. Such a mixture is then called a sample, and this sample should represent the average characteristics of the soil of this field,

both chemically and physically. In some fields, including more than one quality of soil, more than one sample may be necessary, but it usually has been preferred to sample from fields in which only one quality of soil was present, in order that there should be no doubt as to the kind of soil being investigated.

All of the information secured concerning the soil being sampled is written out at the time the soil is being sampled, in duplicate, one copy being placed in the sample bag, and the second copy being retained for use in the office. A tag, tied to the outside of the bag, serves as a third means of identification, and both records and the tag bear the same field number, so that by no means can the former location of any sample of soil be in doubt.

Samples of soil secured by driving the tube down for distances of only six inches into the ground are called soil samples, and are believed to represent that part of the soil most affected by ordinary plowing. Whenever the sample tube is placed in a hole from which a six-inch core already has been removed, and is driven down to the eighteen-inch mark on the outside of the tube, it is evident that the tube then contains the twelve inches of soil which underlie the six inches nearest the surface of the ground. Six cores taken in this manner represent as much material as twelve cores driven down only to the six-inch mark. These six cores, secured by taking samples of the lower parts of the soil from every alternate hole resulting from the upper soil sampling, form the sub-soil samples. The value of the sub-soil sample consists in determining whether the sub-soil contains any ingredients which would be valuable in the soil. If so, this sub-soil could be made available by means of deep plowing.

DISBURSEMENTS OF THE APPROPRIATION.

Following is a statement of the Survey account as on December 6, 1907, according to the Director's Books:

1905.	Balance December 6, 1905		$ 718 87
	Paid out in December, from 7th to 31st		272 95
	Balance January 1, 1906		445 92
1906.	Appropriation March 17, 1906		25,000 00
			$25,445 92
	Expended in 1906:		
	Paid out 1st quarter	$ 748 88	
	Paid out 2nd quarter	5,208 65	
	Paid out 3d quarter	11,487 80	
	Paid out 4th quarter	3,646 02	
			$21,091 35
	Balance on January 1, 1907		4,354 57
1907.	Appropriation available March 17, 1907		25,000 00
			$29,354 57
	Expended in 1907:		
	Paid out 1st quarter	$ 2,831 09	
	Paid out 2d quarter	2,729 78	
	Paid out 3d quarter	8,393 96	
			$13,954 83
			$15,390 74
	Paid out in October	$ 2,371 58	
	Paid out in November	4,308 91	
	Paid out December 1 to 6	1,874 01	
			$8,554 50
	Balance December 6		$6,845 24

Estimated expenditures to March 17 1908:

Salaries	$ 3,045 00	
Field expenses	425 00	
Cooperative mapping	2,607 00	
Office	133 00	
Museum	100 00	
Laboratories	250 00	
Freights	100 00	
Sundries	185 00	
		$6,845 00

Following is a statement of disbursements in detail, arranged according to the headings under which they fall in the distribution of allotments in the work of the Survey, from December 6, 1905, to December 6, 1907:

ON ACCOUNT OF GEOLOGY.

1905.		Pay	Expenses.	Total
Dec. 28.	J. H. Gardner, December pay	$ 50 00	$ ------	$ 50 00
Dec. 28.	F. J. Fohs, December pay and expenses	120 00	17 95	137 95
1906.				
Jan. 10.	Schaeffer Art Co., Acc't. of Jan. 2; developing 13 photo plates, 65c; 6 doz. prints, $3.00	------	3 65	3 65
Jan. 31.	F. J. Fohs, pay for January	120 00	------	120 00
Jan. 31.	J. H. Gardner, 3-5 January pay	30 00	------	30 00
Feb. 28.	F. J. Fohs, ½ February pay	60 00	------	60 00
Feb. 28.	J. H. Gardner, 3-5 Feb. pay	30 00	------	30 00
Mch. 31.	F. J. Fohs, balance February pay and pay for March	148 00	------	148 00
Mch. 31.	J. H. Gardner, balance Feb. and Jan. pay, and pay for March	90 00	------	90 00
Mch. 31.	S. A. Denny, pay for March, ½ month	30 00	------	30 00
April 30.	F. J. Fohs, pay for April	120 00	------	120 00
April 30.	J. H. Gardner April pay and expenses	100 00	43 90	143 90
May 7.	S. A. Denny, April pay and expenses	75 00	32 32	107 32
May 31.	F. J. Fohs, May pay and expenses	120 00	64 45	184 45
May 31.	S. A. Denny, May pay and expenses	75 00	43 20	118 20
June 4.	W. F. Pate, pay 6 days in May and expenses	24 00	1 29	25 29

1906.		Pay.	Expenses.	Total.
June 16.	A. M. Miller, pay for May, 1906, and expenses for May, 1905, omitted in former account	$ 50 00	$ 3 23	$ 53 23
June 16.	J. M. Hodge, May pay and expenses	150 00	186 43	336 43
June 16.	J. H. Gardner, May pay and expenses	100 00	78 08	178 08
July 3.	A. F. Foerste, preparing report on Silurian and Devonian Clays, etc.	200 00	------	200 00
July 3.	A. M. Miller, June pay and expenses	50 00	11 45	61 45
July 3.	S. A. Denny, June pay and expenses	75 00	47 45	122 45
July 5.	F. J. Fohs, June pay and expenses	120 00	49 66	169 66
July 5.	J. M. Hodge, June pay and expenses	150 00	153 97	303 97
July 5.	J. H. Gardner, June pay and expenses	100 00	116 10	216 10
July 23.	W. F. Pate, pay 6 days in June and June expenses	24 00	3 77	27 77
July 31.	J. H. Gardner, pay 25 days in July and expenses	83 33	26 19	109 52
July 31.	A. M. Miller, July pay and expenses	50 00	69 84	119 84
Aug. 3.	F. J. Fohs, July pay and expenses	120 00	68 38	188 38
Aug. 3.	S. A. Denny, July pay and expenses	75 00	56 45	131 45
Aug. 3.	A. R. Crandall, July pay and expenses	200 00	43 50	243 50
Aug. 3.	J. M. Hodge, July pay and expenses	37 50	25 98	63 48
Aug. 3.	A. F. Foerste, July pay and expenses	125 00	64 97	189 97
Sept. 1.	S. A. Denny, August pay and ex-			
Sept. 1.	A. R. Crandall, August pay and expenses	200 00	68 91	268 91
	penses	100 00	62 88	162 88
Sept. 3.	F. J. Fohs, August pay and expenses	120 00	71 15	191 15
Sept. 8.	J. M. Hodge, August pay and expenses	150 00	53 55	203 55
Sept. 18.	L. N. Taylor, pay and expenses in August	9 00	10 75	19 75

1906.		Pay.	Expenses.	Total.
Sept. 13.	A. F. Foerste, August pay and expenses for August 1 to Sept. 8, inclusive	$125 00	$34 96	$159 96
Sept. 13.	A. M. Miller; August pay and expenses	50 00	54 99	104 99
Oct. 1.	J. M. Hodge, Sept. pay and expenses	100 00	31 47	131 47
Oct. 2.	F. J. Fohs, Sept. pay and expenses	120 00	45 66	165 66
Oct. 5.	S. A. Denny, Sept. pay and expenses	100 00	75 20	175 20
Oct. 5.	A. M. Miller, Sept. pay and expenses	50 00	52 86	102 86
Oct. 5.	A. F. Foerste, Sept. pay and expenses	62 50	11 35	73 85
Oct. 30.	A. M. Miller, October pay	50 00	------	50 00
Nov. 5.	J. M. Hodge, October pay and expenses	50 00	20 85	70 85
Nov. 5.	F. J. Fohs, October pay and expenses	120 00	50 15	170 15
Nov. 5.	A. F. Foerste, October pay 2-5 mo. and expenses	50 00	12 71	62 71
Nov. 10.	L. N. Taylor, pay and expenses in October	10 00	12 65	22 65
Dec. 5.	F. J. Fohs, November pay and expenses	120 00	15 10	135 10
Dec. 5.	A. M. Miller, November pay	50 00	------	50 00
Dec. 31.	A. F. Foerste, pay for 14 days in November ($58.33) and expenses ($31.72)	58 33	31 72	90 05
Dec. 31.	F. J. Fohs, December pay and expenses	120 00	26 59	146 59
Dec. 31.	J. M. Hodge, pay 1-5 November 4-5 Dec. and expenses Nov. 27-29 and Dec. 1-31	150 00	57 63	207 63
1907.				
Jan. 4.	W. F. Pate, pay and expenses November and December, 1906	38 00	15 82	53 82
Jan. 4.	A. R. Crandall, pay for November and December, 1-2 mo. 1906	100 00	------	100 00
Jan. 12.	A. M. Miller, pay for December 1906	50 00	------	50 00
Feb. 1.	J. M. Hodge, January pay and expense	75 00	75	75 75
Feb. 4.	F. J. Fohs, January pay and expenses	120 00	20 70	140 70

1906.		Pay.	Expenses.	Total.
Feb. 4.	S. A. Denny, January pay and notary fee	$50 00	$ 50	$ 50 50
Feb. 4.	A. M. Miller, January pay	50 00	------	50 00
Mch. 1.	J. M. Hodge, February pay	150 00	------	150 00
Mch. 1.	F. J. Fohs, February pay and expenses	120 00	23 94	143 94
Mch. 1.	A. F. Foerste, February pay	50 00	------	50 00
Mch. 6.	S. A. Denny, February pay and notary fee	50 00	50	50 50
Mch. 6.	A. M. Miller, February pay	50 00	------	50 00
Mch. 30.	F. J. Fohs, March pay and expenses	125 00	75	125 75
Mch. 30.	A. F. Foerste, March pay 1-5 mo.	25 00	------	25 00
April 2.	J. M. Hodge, March pay	100 00	------	100 00
April 2.	A. M. Miller, March pay	50 00	------	50 00
May 1.	F. J. Fohs, April pay and expenses	125 00	44 46	169 46
May 2.	S. A. Denny, April pay and notary fee	50 50	------	50 50
May 2.	A. M. Miller, April pay	50 00	------	50 00
May 31.	F. J. Fohs, May pay and expenses	125 00	1 35	126 35
May 31.	A. M. Miller, May pay	50 00	------	50 00
May 31.	L. E. Nollau, 5 photo negatives and prints of minerals	------	3 50	3 50
June 11.	A. F. Foerste, May pay	25 00	------	25 00
June 29.	F. J. Fohs, June pay	125 00	------	125 00
July 4.	A. R. Crandall, June pay	50 00	------	50 00
July 4.	A. F. Foerste, June pay, 12 days	50 00	------	50 00
July 4.	S. A. Denny, June pay	50 00	------	50 00
July 4.	J. M. Hodge, May pay 1-3 mo. and June pay 1-3 mo.	100 00	------	100 00
July 31.	A. M. Miller, pay and expenses June and July	100 00	62 90	162 90
July 31.	A. R. Crandall, July pay	150 00	------	150 00
July 31.	F. J. Fohs, July pay and expenses	125 00	12 85	137 85
Aug. 30.	A. R. Crandall, August pay 7-8 mo. and expenses July 29 to Aug. 27 inclusive	175 00	62 10	237 10
Aug. 30.	F. J. Fohs, August pay and expenses	125 00	8 75	133 75
Sept. 3.	J. M. Hodge, August pay and expenses	75 00	15 05	90 05

1906.		Pay.	Expenses.	Total.
Sept. 16.	A. M. Miller, August pay and expenses July 29 to Sept. 4 inc.	$ 50 00	$111 80	$161 80
Sept. 16.	A. G. Spillman, collecting large blocks of coal for museum including cost of getting out same and sampling coals for analysis and fuel value testing, June, July and August	------	55 00	55 00
Oct. 1.	F. J. Fohs, September pay and expenses	125 00	2 50	127 50
Oct. 1.	H. D. Easton, pay and expenses for Sept.	75 00	39 37	114 37
Oct. 3.	A. R. Crandall, September pay	100 00	------	100 00
Oct. 3.	J. M. Hodge, September pay	90 00	------	90 00
Oct. 3.	A. M. Miller, September pay	50 00	------	50 00
Nov. 2.	F. J. Fohs, October pay and expenses	125 00	11 50	136 50
Nov. 8.	A. R. Crandall, October pay	50 00	------	50 00
Nov. 8.	A. M. Miller, October pay	50 00	------	50 00
Nov. 27.	J. L. Stewart, making photographs of mine and mill interiors	------	5 00	5 00
Nov. 29.	F. J. Fohs, November pay and expenses	125 00	14 92	139 92
Nov. 29.	A. M. Miller, November pay	50 00	------	50 00
Dec. 6.	J. M. Hodge, Nov. pay and notary fee	50 00	50	50 50
	Total Dec. 6, 1905, to Dec. 6, 1907			**$11,088 01**

SOIL SURVEY AND TESTING.

1907.				
Aug. 2.	A. F. Foerste, pay and field expenses for July	$125 00	$129 58	$254 58
Aug. 2.	Geo. F. Brockman, pay and field expenses for July	50 00	40 00	90 00
Aug. 2.	Graham Edgar, pay and field expenses for July	58 08	56 34	114 42
Aug. 22.	Geo. F. Brockman, expenses Aug. 1-15	------	41 23	41 23
Aug. 22.	A. F. Foerste, expenses July 31-Aug. 13	------	94 70	94 70
Aug. 30.	G. F. Brockman, expenses Aug. 16-26 inclusive and pay Aug. 1-Sept. 1	50 00	62 05	112 05

1907.		Pay.	Expenses.	Total.
Sept. 3.	A. F. Foerste, expenses Aug. 18-27 inclusive and pay for Aug.	$125 00	$78 68	$203 68
Sept. 3.	Graham Edgar, expenses and pay for August	75 00	143 03	218 03
Oct. 1.	G. F. Brockman, expenses Aug. 28-31 inclusive	------	8 44	8 44
Oct. 12.	Graham Edgar, pay 4 days in Sept. and notary	10 25	------	10 25
Nov. 2.	A. F. Foerste, pay 2-5 of Sept. and expenses Aug. 28-Sept. 2 inclusive	50 00	49 49	99 49
Nov. 8.	A. F. Foerste, pay for 2-5 Oct.	50 00	------	50 00
Dec 6.	L. K. Frankel, making blue prints of county maps 70 sq. ft. at 5c	------	3 50	3 50
Dec. 6.	A. F. Foerste, pay for 2-5 Nov. and expenses Nov. 16 to Dec 1	50 00	35 84	85 84
Aug. 2.	Graham Edgar, pay and field expenses for July	58 08	56 34	114 42
	Total to December 6, 1907			$1,386 21

MISCELLANEOUS MAPPING, DRAFTING, OIL AND GAS.

1905.		Pay.	Expenses	Total.
Dec. 28.	J. S. Shaw, (account mapping) pay for December	60 00	------	60 00
1906.				
Jan. 31.	J. S. Shaw, one-half salary for January	30 00	------	30 00
Mch. 31.	J. S. Shaw, balance pay for January	30 00	------	30 00
Mch. 31.	J. S. Shaw, pay for March	60 00	------	60 00
April 30.	J. S. Shaw, pay for April	60 00	------	60 00
May 15.	J. S. Shaw, pay and expenses, April 30, May 10	17 37	45 85	63 22
July 3.	H. B. Pope, (account mapping) pay ½ June and expenses	25 00	2 65	27 65
July 3.	J. B. Hoeing, (account drafting) and petroleum), June pay	125 00	------	125 00
July 31.	J. B. Hoeing, July pay	125 00	------	125 00
July 31.	C. C. Terry, Livery for H. B. Pope and party for July	------	26 00	26 00
	H. B. Pope, pay and expenses for July	50 00	42 25	92 25

1905.		Pay.	Expenses.	Total.
Aug. 3.	C. C. Terry, Board of H. B. Pope in July	------	$20 25	$ 20 25
Aug. 3.	Dixie Jacob, Livery for H. B. Pope in July	------	8 00	8 00
Aug. 3.	G. F. Brockman, rodman	$ 25 00	40 10	65 10
Aug. 9.	W. W. Shelby, Jr., rodman	25 00	18 55	43 55
Aug. 9.	C. C. Terry, Board for Shelby, parts of days July 1-19 and July 26-31, inclusive	------	20 00	20 00
Sept. 1.	J. B. Hoeing, August pay	125 00	------	125 00
Sept. 3.	G. F. Brockman, pay and expenses (August)	25 00	41 70	66 70
Sept. 3.	H. B. Pope, pay and expenses (August)	50 00	102 15	152 15
Sept. 3.	Cerulean Springs Hotel, Board of H. B. Pope, August 28-31, inclusive	------	4 05	4 05
Sept. 3.	R. R. Turney, Livery for H. B. Pope, August 27-31, inclusive	------	12 00	12 00
Sept. 3.	W. W. Shelby, Jr., pay and expenses, August	25 00	30 55	55 55
Sept. 3.	R. S. Pool, board of W. W. Shelby, Jr., Aug. 27 to Sept. 1	------	8 00	8 00
Sept. 8.	W. W. Shelby, Jr., expenses August 21-27	------	6 85	6 85
Sept. 8.	W. W. Shelby, Jr., pay and expenses, September 3	1 65	3 40	5 05
Oct. 1.	H. B. Pope, pay and expenses for September	50	85 45	135 45
Oct. 1.	Howard Brame, Livery for H. B. Pope, and party, September	------	17 50	17 50
Oct. 1.	J. P. Davis, board of H. B. Pope, 4 days in September	------	4 00	4 00
Oct. 1.	G. F. Brockman, pay and expenses in September	1 00	8 25	9 25
Oct. 1.	J. B. Hoeing, September pay	125 00	------	125 00
Oct. 30.	J. B. Hoeing, October pay	125 00	------	125 00
Oct. 30.	J. B. Hoeing, expenses to Dayton, O., and return in re maps	------	8 60	8 60
Nov. 5.	H. B. Pope, pay and expenses for October	50 00	68 15	118 15
Nov. 5.	W. E. West, pay as temporary rodman, in Oct., for H. B. Pope, and notary fee	------	7 25	7 25

1906.		Pay.	Expenses.	Total.
Nov. 5.	Joal Clark, pay as temporary rodman in Oct. for H. B. Pope, and notary fee	------	$ 7 25	$ 7 25
Nov. 5.	J. P. Bowling, Board of H. B. Pope, in October	------	8 75	8 75
Nov. 5.	Walter Armstrong, livery for H. B. Pope and party in Oct.	------	13 75	13 75
Nov. 30.	J. B. Hoeing, pay for Nov.	125 00	------	125 00
Dec. 5.	H. B. Pope, pay and expenses for November	50 00	69 20	119 20
Dec. 5.	Q. M. Curvey, board for H. B. Pope, in November	------	11 00	11 00
Dec. 5.	Wallingford & Foster, livery for H. B. Pope and party in Nov.	------	42 00	42 00
Dec. 31.	H. B. Pope, pay and expenses for December	50 00	15 70	65 70
Dec. 31.	J. B. Hoeing, December pay	125 00	------	125 00
Dec. 31.	J. B. Hoeing, expenses to Barbourville, Pineville, &c., in			
1907.	December	------	12 42	12 42
Feb. 1.	J. B. Hoeing, (pay for January	80 00	------	80 00
Feb. 1.	J. B. Hoeing, sample sacks	------	2 75	2 75
Feb. 1.	H. B. Pope, pay for January	50 00	------	50 00
Mch. 1.	H. B. Pope, pay for February	50 00	------	50 00
Mch. 1.	J. B. Hoeing, pay for February	100 00	------	100 00
Mch. 30.	J. B. Hoeing, pay for March	125 00	------	125 00
May 1.	J. B. Hoeing, pay and expenses for April	112 50	4 80	117 30
May 1.	P. S. Wilson, (draftsman) pay April 3-10 mo. at $100.00	30 00	------	30 00
May 31.	P. S. Wilson, pay for May	100 00	------	100 00
May 31.	J. B. Hoeing, pay and expenses for May	125 00	4 70	129 70
June 11.	J. M. Dyer, services and expenses in running line of levels in Crittenden county in May	30 00	24 55	54 55
	W. J. Waller, services and expenses as assistant to J. M. Dyer	14 00	11 90	25 90
June 29.	J. B. Hoeing, pay and expenses for June	115 00	17 10	132 10
June 29.	P. S. Wilson, pay for June	100 00	------	100 00
July 4.	W. W. Shelby, Jr. (oil well mapping), pay for June 1-2 mo. and expenses	25 00	58 50	83 50
July 4.	J. W. Norton, rodman, pay for June 1-6 mo. and expenses	4 17	14 80	18 97

1907.		Pay.	Expenses.	Total.
July 4.	S. B. Price, rodman, pay for June 1-6 mo. and expenses----	$ 4 17	$14 76	$ 18 93
July 31.	J. B. Hoeing, pay and expenses July ----------	125 00	(3 00)	128 00
July 31.	P. S. Wilson, pay for July---	100 00	------	100 00
Aug. 2.	J. W. Norton, pay and expenses for July ----------	25 00	23 93	48 93
Aug. 2.	S. B. Price, pay and expenses for July ----------	25 00	22 88	47 88
Aug. 2.	W. W. Shelby, Jr., pay and expenses for July ----------	50 00	74 38	124 38
Aug. 2.	Mrs. J. W. Pedigo (Glasgow), livery for W. W. Shelby, Jr. and party in July ----------	------	39 00	39 00
Aug. 2.	J. C. Jenkins, lodging and meals for W. W. Shelby, July 17 to 31 inclusive---------- Same for J. W. Norton, July 17th to 31st inclusive, less one meal ---------- Same for S. B. Price, July 17th to 31st, inclusive, less one meal Lunch for team driver---------	------	48 93	48 93
Aug. 17.	S. B. Price, pay and expenses Aug. 1, to 10 ----------	8 34	19 07	27 41
Aug. 17.	J. W. Norton, pay and expenses, Aug. 1, to 10 ----------	8 34	8 94	17 28
Aug. 30.	W. W. Shelby, Jr., expenses Aug. 9th to 24th inclusive and pay for August, (oil well Sur.)	50 00	137 73	187 73
Aug. 30.	J. B. Hoeing, pay for August	125 00	------	125 00
Sept. 3.	P. S. Wilson, pay for August	100 00	------	100 00
Sept. 17.	W. W. Shelby, Jr., expenses Aug. 28 to Sept. 2, inclusive and pay for 1-2 September, (oil well survey) ----------	25 00	71 97	96 97
Oct. 1.	J. B. Hoeing, pay for September	125 00	------	125 00
Oct. 3.	Wallace Newberger, for drafting and computing field notes, 1-2 mo. September ----------	30 00	------	30 00
Nov. 2.	J. B. Hoeing, pay and expenses for October ----------	125 00	(19 75)	144 75
Nov. 29.	J. B. Hoeing, pay and expenses for November ----------	125 00	(15 09)	140 09
	Total, December 6, 1905 to December 6, 1906-----			$5,121 69

OFFICE ACCOUNT.

1905.			Total.
Dec.	28.	James Mack, janitor, pay for December	$25 00
1906.			
Jan.	11.	Roger Harp & Bro., account rendered Jan.: Oct. 11, 1905, mop, 45c.; Dec. 28, 1905, soap, 1 broom, 45c.;	90
Jan.	11.	Items from Director's account as follows: Nov. 7, 1905, rent to telephone no. 1012, for Aug., Sept., and Oct. $3.00 and tolls, $2.50	5 50
		Jan. 9, 1906, P. O. Box rent, quarter ending Mch. 31	1 00
		Jan. 10, 1906, rent to telephone No. 1012, Nov., Dec. and Jan. $3.00 and tolls $2.50	5 50
		Jan. 10, 1906, rent telephone No. 1540 quarter ending March, 31	6 00
Jan.	31.	Jas. Mack, pay for January	25 00
Feb.	28.	Jas. Mack, pay for February	25 00
Mch.	31.	Jas. Mack, pay for March	25 00
April	4.	Items from Director's account as follows:	
		Feb. 10, rent telephone No. 1012 for February $1.00 and Jan. tolls $1.45	2 45
		Mch. 1, rent telephone No. 1012 for March, $1.00 and Feb. tolls, $2.85	3 85
		April 2, P. O. Box rent, quarter ending June 30	1 00
		April 3, rent telephone No. 1012 for April	1 00
		April 3, rent telephone No. 1540, quarter ending June 30	6 00
April	4.	J. M. Byrnes, account rendered Jan. 26., 250 letter circulars	2 50
April	18.	Items from Director's account as follows:	
		April 2, paid H. B. Pope, work in office Oct. 1, 1905 to April 1, 1906	30 00
		April 9, telegram to Washington (Wilson)	40
		April 16, telegram to Cincinnati (Hodge)	25
		April 17, J. W. Norwood, account fee for notary commission for survey, $2.00 and rubber stamp .25	2 25
April	30.	Jas. Mack, pay for April	25 00
May	8.	Items from Director's account as follows:	
		April 26, telegram	39
		April 30, E. M. Collins, typewriting 5 3-4 days	5 75
		May 2, 2 telegrams	1 08
		May 2, rent telephone No. 1012 for May, $1.00 and April tolls, $0.70	1 70
		May 2, telegram from Milton, Wis.	68
		May 5, H. B. Pope, work in office, April	5 00
		May 5, W. L. English, typewriting 1 1-2 day	1 50
		May 5, Rhoda Miller, typewriting 4 1-2 days	4 50

1906.		Total.
June 6.	Jas. Mack, pay for May	$25 00
June 6.	F. G. McKay, pay 2-3 month of May	40.00
June 11.	Items from Director's account as follows:	
	June 1, H. B. Pope, work in office, May	5.00
	June 2, Eight telegrams	4.10
	June 6, One telegram	.55
	June 8, Rent telephone No. 1012, for June ($1) and May tolls ($1)	2.00
July 3.	F. G. McKay, Clerk, pay for June	60.00
July 3.	Items from Director's account as follows:	
	June 24, Telegrams, Two from Marion	.54
	July 2, Rent, Telephone No. 1012 for Quarter ending Sept. 30., ($3.) and June tolls ($1.15)	4 15
	July 2, Jas. Mack, janitor, pay for June	25.00
	July 2, Rent, Telephone No. 1540 for Quarter Ending Sept. 30.,	6.00
	July 2, Rent P. O. Box, for Quarter Ending Sept. 30.	1.00
July 23.	Postage Stamps	30.00
July 31.	F. G. McKay, Clerk, pay for July	60.00
July 31.	Jas. Mack, Janitor, pay for July	25.00
Aug. 9.	Items from Director's account as follows:	
	July 5, telegram, Big Stone Gap	46
	July 6, telegram, Big Stone Gap	67
	July 11, telegram, from Morganfield	26
	July 11, telegram from Straight Creek	55
Aug. 9.	Items from Director's account as follows:	
Sept. 1.	Items from Director's account as follows:	
	Aug. 9, telegram to Beaver Dam	45
	Aug. 13, cash refunded State Geologist of Indiana, for express	90
	Aug. 28, drawing pens	30
	Aug. 31, telephone tolls for August	50
Sept. 1.	F. G. McKay, clerk, pay for August	60 00
Sept. 1.	Jas. Mack, janitor, pay for August	25 00
Sept. 3.	Roger Harp & Bro., account as follows:	
	Feb. 6, 1 duster, 40c, rub-no-more, 05c	45
	May 11, 1 broom, 35c; pearline, 10c	45
	Aug. 1, 1 broom, 30c; pearline, 10c; soap, 05c; Ivory soap, 10c	55
Sept. 13.	Fellmer Hoeing, inserting maps in Big Sandy report 6 1-2 days	8 00
Oct. 1.	F. G. McKay, clerk, pay for September	60 00

1906.			Total.
Oct.	1.	Jas. Mack, janitor, pay for September	$25 00
Oct.	2.	Items from Director's account as follows:	
		Oct. 1, rent telephone No. 1012, for quarter ending December 31.	6 00
		Oct. 1, rent telephone No. 1540, for quarter ending December 31.	6 00
		Tolls on telephone No. 1540 in June	15
		Oct. 1, P. O. Box rent, for quarter ending December 31	1 00
		Telegram to Louisville, September 29	51
Oct.	9.	Transylvania Co.'s account as follows:	
		April 30, box photo plates	35
		June 25, glass in frames for maps	7 50
		Sept. 15, trimming maps	25
Oct.	30.	F. G. McKay, clerk, pay for October	60 00
Oct.	30.	Jas. Mack, janitor, pay for October	25 00
Oct.	30.	Wallace Newberger, work in office and museum in Oct.	10 00
Oct.	30.	2 pads for stencil stamp, from Director's account	45
Nov.	30.	Items from Director's account as follows:	
		Nov. 1, 2 telegrams	89
		Nov. 1, telephone tolls for October	65
		Nov. 23, telegram to Middlesboro	25
		Nov. 30, telegram from Big Stone Gap (Nov. 26)	40
		Nov. 30, telephone tolls for November	40
Nov.	30.	F. G. McKay, clerk, pay for November	60 00
Nov.	30.	Jas. Mack, janitor, pay for November	25 00
Dec.	5.	Wallace Newberger, work during November	7 00
Dec.	22.	F. G. McKay, clerk, pay for December	60 00
Dec.	22.	Jas. Mack, janitor, pay for December	25 00
Dec.	31.	Items from Director's account follows:	
		Dec. 5, telegram to Louisville	25
		Dec. 26, telegram to Louisville	49
		Dec. 31, P. O. Box rent, for quarter ending March 31, 1907	1 50
		Dec. 31, telegram to Dayton, Ohio	25
		Dec. 31, telegram to New York, N. Y.	61
1907.			
Jan.	4.	Jas. M. Byrnes, account as follows:	
		Aug. 28, 1906, 1,000 tags, 60c; glue 25c	85
		Jan. 2, 1907, 500 circulars	3 00
Jan.	4.	Items from Director's account as follows:	
		Jan. 4, rent telephone No. 1012 for quarter ending March 31	6 00
		Jan. 4, rent telephone No. 1540, for quarter, ending March 31	6 00

1907.			Total.
Jan.	4.	Roger Harp & Bro's. account as follows:	
		March 8, 1906, 1 Mop 40c, pearline 15c, 1 duster 40c	$ 95
Feb.	1.	Jas. Mack, janitor, pay for January	25 00
Feb.	1.	F. G. McKay, clerk, pay for January	60 00
Feb.	4.	Items from Director's account as follows:	
		Feb. 2, ink pad	25
		Feb. 2, telephone tolls for January	1 90
Mch.	1.	F. G. McKay, clerk, pay for February	60 00
Mch.	1.	Jas. Mack, janitor, pay for February	25 00
Mch.	1.	N. D. Bentley, typewriting, &c., 4 days in February	5 00
Mch.	1.	Kaufman, Straus & Co., towels	5 25
Mch.	4.	Items from Director's account as follows:	
		Mch. 16, telegram to Greenville	65
		Mch. 1, towel roller bar	10
		Mch. 1, telephone tolls for February	65
Mch.	30.	F. G. McKay, clerk, pay for March	60 00
Mch.	30.	Jas. Mack, janitor, pay for March	25 00
Mch.	30.	Transylvania Co's. account as follows.	
		Feb. 14, Letter Scales	1 75
		Feb. 15, 2 pencils	20
Mch.	30.	N. D. Bentley, typewriting and copying reports for March	35 00
April	2.	Items from Director's account as follows:	
		March 30, P. O. Box rent, for quarter ending June 30	2 00
		April 2, rent telephone No. 1012, for quarter ending June 30	6 00
		April 2, rent telephone No. 1540, for quarter ending June 30	6 00
April	2.	Frazer & Bush, account for fixing electric lights, and 2 stand lamps in office	11 84
April	15.	Roger Harp & Bro's. account as follows:	
		June 17, 1 Broom 35c, 3 pkgs. pearline, 15c	50
		Feb. 13, 3 pkgs. pearline 10c, (28) 4 bars soap 20c, sapolio 10c	40
		Mch. 7, 6 bxs. rub-no-more 30c, 6 bars soap 20c, 1 broom 40c	90
		Mch. 7, 1 mop 40c, (14) 6 bxs. pearline 30c	70
April	15.	Transylvania Co's. account as follows:	
		Mch. 1, 1 quart ink	75
May	1.	F. G. McKay, clerk, pay for April	60 00
May	1.	Jas. Mack, janitor, pay for April ($25), extra time in Museum ($5), and washing office towels (50c)	30 50
May	1.	N. D. Bentley, typewriting and copying reports for April	35 00
May	2.	East Tennessee Telephone Co., tolls for April	2 85

1907.		Total.
May 2.	Items from Director's account as follows:	
	April 1, 6 telegrams in April, Postal Tel. Co	$ 3 32
	May 1, telegram in April, Western Union Co	25
May 2.	Jas. M. Byrnes, account as follows:	
	Feb. 26, stenographer's note books	50
May 31.	F. G. McKay, clerk, pay for May	60 00
May 31.	Jas. Mack, janitor, pay for May ($25) and washing office towels (50c)	25 50
May 31.	N. D. Bentley, typewriting and copying reports in May	35 00
June 11.	Jas. M. Byrnes, printing corrections on letter heads	1 00
June 11.	Item from Director's account as follows:	
	June 4, telegram in May	25
June 29.	F. G. McKay, clerk, pay for June	60 00
June 29.	Jas. Mack, janitor, pay for June ($25) and washing office towels (50c)	25 50
June 29.	N. D. Bentley, typewriting and copying reports for June	35 00
July 4.	East Tennessee Tel. Co., rent on telephone No. 1012, for quarter ending Sept. 30, ($6) and June tolls ($1.05)	7 05
July 4.	Fayette Home Tel. Co., rent on telephone No. 1540, for quarter ending Sept. 30	6 00
July 4.	Items from Director's account as follows:	
	June 26, rent P. O. box, for quarter ending Sept. 30	2 00
	July 1, telegrams for June	4 77
July 31.	F. G. McKay, clerk, pay for July	60 00
July 31.	Jas. Mack, janitor, pay for July ($25) and washing office towels, (50c)	25 50
July 31.	N. D. Bentley, typewriting and copying reports for July	35 00
July 31.	Roger Harp & Bro's., account of July 1, as follows:	
	April 26, 4 boxes pearline 20c, 2 bars soap 20c, duster 50c	90
	June 22, 1 broom	40
July 31.	McClure & Bronston, account as follows:	
	Sept. 12, 1906, 1000 cards for card index	1 25
Aug. 2.	S. M. Brown, furnishing and fitting locks for book-cases	7 00
Aug. 2.	Items from Director's account as follows:	
	Telegrams in July	1 88
	Telephone tolls in July	1 50
Aug. 22.	L. K. Frankel, for making 51 blue-prints of county maps, 246 sq. ft. at 5c	12 30
	1 yard of tracing cloth	40
Aug. 30.	N. D. Bentley, copying and typewriting reports for August, 6 days	6 78
Aug. 30.	F. G. McKay, clerk, pay for August	60 00

1907.		Total.
Aug. 30.	Jas. Mack, janitor, pay for August ($25) and washing office towels (50c)	$25 50
Oct. 1.	F. G. McKay, clerk, pay for September	60 00
Oct. 1.	Jas. Mack, janitor, pay for September $25) and washing office towels (50c)	25 50
Oct. 1.	N. D. Bentley, copying and typewriting reports for September	35 00
Oct. 1.	East Tenn. Tel. Co., rent of telephone No. 1012, for quarter ending Dec. 31	60 00
Oct. 1.	Fayette Home Tel. Co., rent of telephone No. 1540, for quarter ending Dec. 31	6 00
Oct. 1.	Items from Director's account as follows:	
	Aug. 31, Western Union Tel. Co., telegrams in August	1 88
	Sept. 1, East Tenn. Tel. Co., tolls in August	95
	Sept. 27, P. O. Box rent, for quarter ending Dec.31	2 00
Oct. 3.	Jas. M. Byrnes, account as follows:	
	Sept. 12, 4 clips	60
	Sept. 21, 1000 pinch clips 90c.; 1 Letter Scale ($3)	3 90
	Sept. 21, 24 Desk Blotting Pads	1 00
Oct. 18.	Items from Director's account as follows:	
	Oct. 4, 2 boxes for shipping books	0 20
	Oct. 4. Hauling boxes to office	25
	Oct. 4, telephone message in September	25
Nov. 2.	N. D. Bentley, copying and typewriting reports for October	35 00
Nov. 2.	F. G. McKay, clerk, pay for October	60 00
Nov. 2.	Jas. Mack, janitor, pay for October ($25) and washing office towels (50c)	25 50
Nov. 8.	Items from Director's account as follows:	
	Oct. 30, telegram to U. S. Geological Survey, Washington	56
	Nov. 5, East Tenn. Tel. Co., tolls for October	2 55
	Nov. 5, Western Union Tel. Co., telegrams in October	1 56
Nov. 13.	Postage Stamps	50 00
Nov. 29.	F. G. McKay, clerk, pay and expenses for November	63 10
Nov. 29.	Jas. Mack, janitor, pay for November ($25) and washing office towels (50c)	25 50
Nov. 29.	N. D. Bentley, copying and typewriting reports for November	35 00
Dec. 6.	Jas. M. Byrnes, account as follows:	
	Nov. 16, 6 bottles paste ($1.50), 1000 fasteners ($1.50)	3 00

1907.			Total.
Dec.	6.	Western Union Telegraph Co's. account for November:	
		Nov. 8, telegram to Columbus (Easton) (35c), (11) to London (25c)	$ 0 60
		Nov. 12, telegram to Louisville, (27c), to Washington D. C. (50c)	77
		Nov. 13, telegram to Louisville (25c), to Washington, D. C. (83c)	1 08
		Nov. 26, telegram to N. Y. C. (88c), Scranton, (70c) Chicago (45c), Washington, D. C. (68c)	2 71
		Nov. 29, telegraph to Boston, Mass	1 00
Dec.	6.	Item from Director's account as follows:	
		Dec. 4, telephone tolls in November	25
		Total, December 6, 1905, to December 6, 1907	$2,423 03

MUSEUM.

1906.			
Oct.	30.	Item from Director's account:	
		Paid Will Johnston and helper for moving cases	$ 0 80
Dec.	5.	Combs Lumber Co., partition built across end of Museum, and shelves	64 90
1907.			
Feb.	4.	Combs Lumber Co., partition and shelving, (lumber and workmen)	76 98
Feb.	4.	Item from Director's account:	
		Two men, 1 day each, moving cases	2 50
Mch.	1.	S. M. Brown, making 3 map cases ($51.35) and making board for map ($3)	54 35
Mch.	6.	W. L. Maclean, repainting relief geological map of State, on account	15 00
April	2.	Geo. F. Brockman, work in museum, March 19 to 30, inclusive	10 00
April	15.	Harp Bro's. account as follows:	
		March 18, 4 barrels	60
		March 26, 4 barrels	60
April	15.	W. L. Maclean, balance on repainting relief map of State	15 00
April	15.	S. M. Brown, 2 map cases complete ($33.50) and blocks ($21.75) for specimens, and 8 boxes ($5)	60 25
May	2.	J. M. Byrnes, 4,320 card labels for specimens, 22 forms	28 25
May	2.	Geo. F. Brockman, 16 2-3 hours, work in April	2 50
May	2.	Wallace Newberger, drawing large "economic" geology chart	5 00
May	31.	L. H. Ramsey & Co. lettering large geological relief map of State	60 00

1907.			
June	11.	Item from Director's account: May 28, W. W. Shelby, work in April	$ 1 50
Aug.	17.	Item from Director's account: Mose Holeman, labor, 1 day	1 50
		Total, December 6, 1905, to December 6, 1907	$ 399 73

CHEMISTRY AND CHEMICAL LABORATORY.

1906.			
July	2.	A. M. Peter, analyses to July 1	$ 60 00
Aug.	13.	Chase Palmer, analyzing 14 coals	70 00
Oct.	1.	A. M. Peter, analyses to October 1	197 50
Nov.	5.	A. M. Peter, analyses in October	80 00
Dec.	5.	A. M. Peter, analyses in November	55 00
Dec.	5.	Combs Lumber Co., scales case, $19.50, and broken glass in same replaced, $1.25 (November)	20 75
1907.			
Feb.	4.	A. M. Peter, analyses to February 1	25 00
Mch.	6.	A. M. Peter, analyses to Mch. 1	182 50
May	2.	Geo. F. Brockman, ½ month in April, pay	12 50
May	31.	McAdams & Morford, Chemical Supplies	2 25
June	11.	Geo. F. Brockman, testing coals, 1 month, May	25 00
June	29.	Geo. F. Brockman, testing coals, 1 month, June	25 00
June	29.	Wallace Newberger, compiling new Chemical Bulletin, 1-10 month, June	6 00
July	4.	F. E. Tuttle, account of chemical analyses, for June	50 00
July	31.	W. Newberger, Compiling new Chemical Bulletin, July	60 00
Aug.	2.	A. M. Peter, for thermometer to replace broken one, ($9.00) chemicals, ($6.00) and expressage, (85c), account fuel testing	15 85
Aug.	17.	F. E. Tuttle, chemical analyses, July	50 00
Aug.	30.	Wallace Newberger, drafting & compiling new Chemical Bulletin, August	60 00
Aug.	30.	F. E. Tuttle, chemical analyses, August	50 00
Sept.	3.	Standard Calorimeter Co., (E. Moline, Ill.) Aug. 24, 1 Calorimeter, electric ignition, and chemicals	153 25
Nov.	27.	Queen & Co., account as follows: Nov. 11, 2 8-foot wall cabinets for laboratory, ($144); 1 double section chemical laboratory table with slate top, ($63)	207 00
Nov.	29.	A. M. Peter, chemical work in Nov.	50 00
Dec.	6.	Lexington Plumbing Co., account of Dec. 4, 1 No. 6 Crescent Instantaneous water heater for laboratory	20 00

1907.				
Dec.	6.	Queen & Co., account, Dec. 5. (second shipment):		
		1 double section laboratory table		$ 63 00
Dec.	6.	Eimer & Amend. (New York) account for Chemicals (Dec. 4)		56 01
Dec.	6.	Eimer & Amend, (New York) account for Apparatus (Dec. 4)		679 33
		Total, December 6, 1905, to December 6, 1907		$2,275 94

TECHNOLOGY OF CLAYS, ETC.

1907.				
Aug.	30.	H. D. Easton, pay and field expenses for August, 26 days		$112 42
Nov.	8.	H. D. Easton, pay for October and notary fee		75 25
Nov.	29.	H. D. Easton, pay and traveling expenses for November		90 20
		Total for 1907, to December 1		$ 277 87

TESTINC LABORATORY EQUIPMENT.

1907.				
Aug.	22.	Blake Mining & Milling Co., (Denver, Colo.):		
		1 static electric ore testing machine		$ 77 03
Oct.	3.	The Black Sand & Gold Recovery Co., (Chicago):		
		Oct. 1, 1 Laboratory Electric Testing Machine, for testing ferruginous sands, sandstones, earthy iron ores, glass sands, &c.		100 00
Oct.	12.	R. V. Wagner Co., (Chicago):		
		1 Static generator for Blake-Morscher ore testing machine		150 00
Nov.	27.	Sturtevant Mill Co., account of Nov. 25:		
		Laboratory apparatus for testing ores, coals and clays, and road materials;		
		1, 2 x 6 crusher	$125 00	
		1, 8 x 5 rolls	150 00	
		1 sample grinder	100 00	
		1 screening machine	50 00	
				$425 00
Nov.	27.	H. J. Caulkins and Co.:		
		1 "Revelation" pottery and brick kiln	$175 00	
		Accessories for same	50 00	
				$225 00
Nov.	27.	Henry Heil Chem. Co., account of Nov. 25:		
		1 Braun's combination kiln, for testing clays	$75 00	
		1 Braun's No. 26 furnace and gas burner for glazed ware, vitrifying clay and high heats, with combination motor-blower	87 50	

1907.		1 Cary douple muffle furnace No. 37 with Cary burner, 2 1-4 inches, and tank No. 102 ---------- ----------	83 00	
				$245 50
Nov.	27.	R. V. Wagner Co., (Chicago), account of Nov. 26: 1 Combination motor and belt, for operating static ore testing machine ----------		65 00
		Total, December 1905 to December 1906----------		$1,287 53

CHEMICAL AND TECHNICAL LIBRARY.

1907.			
Oct.	12.	Hill Publishing Co., Aug. 31, 3 Volumes Mineral Industry ----------$	13 50
Dec.	6.	Jno. M. Greenway, Dec. 3, miscellaneous technical and chemical books ----------	214 20
		Total ----------$	227 70

GENERAL EQUIPMENT, REPAIRS, ETC.

Feb.	28.	Keuffel & Esser Co., repairs on barometers in April, 1905, (delayed account) ----------$	4 50
June	5.	Keuffel & Esser Co., account as follows: May 28, 1 compass, $11.90; 1 boxwood scale, 30c; 1 protractor, 36c; ½-doz. cross section books, $2.63; 1 screw for target on No. 6260, 60c; 1 bronzed sight compass, $5.80, and postage 10c----------	21 69
June	11.	L. M. Prince, 10 yds. 42-inch. No. 38 Sup. Sup. Eggshell mounted drawing paper, (June 2)----------	8 70
Nov.	10.	Keuffel & Esser Co., account of Oct. 17: 1 qr. Whatman's paper, Royal Hot P, 1 A., ($1.19); 1 dozen inks (4 colors), Higgins, ($2.25); 1 card crow-quill pens, 35c----------	3 79
Oct.	9.	Smith Premier Typewriter Co., 1 Desk, (No. 20, Cabinet) ----------	42 75
Oct.	30.	McClure & Bronston, 2 Index Files and Fittings------	8 95
Oct.	30.	Smith Premier Typewriter Co., 1 Typewriter----------	90 00
Dec.	31.	C. H. Bowen, No. 3 Burroughs Adding Machine------	250 00
1907.			
Jan.	12.	Eimer & Amend, account for apparatus, etc.*	
		Hoskins furnace and blow pipe----------$ 46 00	
		Assay balance, weights & riders---------- 123 22	
		Sample crusher, (Case) ---------- 35 00	
		Scales for fluxes ---------- 7 20	

* This should have been charged to Chemical Laboratory.

1907.

	Ruedorff Sand Bath	$ 8 00	
	Mortars (Buck's and Agate)	14 15	
	Set of sieves	4 00	
	Dangler lamp	5 00	
	Tongs, pliers, brushes, flasks, moulds, forceps, hammers, spatulas, magnifier, magnet, pasteboard boxes, annealing cups, triangles	20 58	
	Chemicals	52 74	
			$ 315 89

1907.

Feb. 4.	Keuffel & Esser Co., drawing instruments, (Dec. 13, 1906)	$	6 62
Mch. 1.	S. M. Brown, making 2 tables, ($6.50) and 1 trestle, ($2.75)		9 25
Mch. 6.	Elmer & Amend, sample bottles, corks, sieves and cupels		6 35
Mch. 6.	Keuffel & Esser Co., level rod		9 60
April 15.	Keuffel & Esser Co., account as follows: Mch. 26, 2 qrs. Std. cross section paper No. 280 blue, $4.90; 10 yds. plumb bob cord, 40c; 1 Aladdin reading lens, $9.60; 1 renewal batty for same, 42c		15 32
	April 5, 2 Standards for mining lamp plummets		35 70
April 15.	Smith Premier Typewriter Co., 1 Typewriter		87 75
April 15.	Transylvania Co., 2 dozen photo. plates		70
May 1.	Southern Printers Supply Co., (Washington), 6 electrotype half tones		5 60
July 4.	H. Pfister, repairing transit in June		24 50
July 31.	Smith, Watkins & Co., account of July 1: Mch. 29, screw driver bit 25c; nail puller 75c; 2 monkey wrenches $1.90; 4 lbs. 4 penny nails 10c.		3 05
Aug. 17.	Item from Director's account: Brock & Co., tin tube for maps		1 00
Sept. 3.	Keuffel & Esser Co., 1 roll mounted paragon paper 111—42 inches, $6.51; 2 qrs. Whatman's paper No. 1 A, Imp. Hot., $3 96; 1 roll Excelsior tracing paper 150—42 inches, $10 60; 1 roll Corona tracing paper 195M—42 inches, $2.53, on August 28		23 60
Nov. 8.	T. B. Hay & Co., repairing tapeline on Nov. 1		50
Nov. 29.	Keuffel & Esser Co., account of Nov. 14: 1 measuring chain, $5.60; 1 set steel arrows, $1.13; 1 leather pouch for arrows, $2.80; 1 champion band chain, $7.50		17 03

1907.			
Dec.	6.	Keuffel & Esser Co., account of Nov. 30: 1 Xylonite Protector, $2 25; 1 hardwood Jacob staff 85c; 1 bow divider, 73c; 2-foot steel rule 34c, with leather sheath, 4c; 1 dozen thumb tacks, 12c	$ 4 33
		Total, December 6, 1905, to December 6, 1907	$ 997 17

FREIGHT AND DRAYAGE.

1906.			
Jan.	15.	Adams Express Co., bill Dec. 4, 1905 to Dec. 8, 1905	$ 1 95
Feb.	28.	Farley Transfer & Storage Co., bill of Jan. 1, freights and cartage on boxes of minerals	12 08
Mch.	26.	Adams Express Co., bill of July 12, 1905, (delayed bill) and Jan. 25, 1906	60
May	29.	Adams Express Co., bill April 28 to May 21	3 20
July	31.	Adams Express Co., bill May 31 to June 23	2 80
Sept.	1.	Adams Express Co., bill July 30 to Aug. 15	2 00
Oct.	30.	J. E. Risque, hauling April 13 to Oct. 8	7 84
Nov.	5.	Adams Express Co., bill Aug. 30 to Oct. 31	2 90
Dec.	6.	Adams Express So., bill Nov. 12 to Nov. 28	1 65
Dec.	31.	J. H. Hostetter Transfer Co., drayage	2 41
1907.			
Jan.	2.	Adams Express Co., bill for December, 1906	4 75
Jan.	25.	Adams Express Co., bill for January	1 20
Mch.	1.	Adams Express Co., bill for February	35
Mch.	30.	Adams Express Co., bill Feb. 25 to Mch. 2	3 75
April	26.	Adams Express Co., bill Mch. 22 to April 24	6 80
May	28.	Adams Express Co., bill May 15	1 75
June	29.	Adams Express Co., bill for June	3 40
July	4.	J. H. Hostetter Transfer Co., freights and drayage, Jan. 11 to May 1, inclusive	24 96
July	26.	Adams Express Co., bill June 28 to July 11	2 00
July	31.	Farley Transfer & Storage Co., freights and drayage, Aug. and Dec., 1906 and February, 1907	4 33
Aug.	28.	Adams Express Co., bill Aug. 20 to Aug. 27	5 37
Sept.	3.	Farley Transfer & Storage Co., freights and drayage, for August	9 93
Sept.	28.	Adams Express Co., bill Aug. 29 to Sept. 13	4 45
Nov.	8.	J. H. Hostetter Transfer Co., freights and drayage, Sept. 16 to Oct. 4, inclusive	26 52
Nov.	29.	Farley Transfer & Storage Co., freights and drayage, Aug. 15 to Sept. 19, inclusive	35 88
Dec.	2.	Adams Express Co., bill Oct. 31 to Nov. 29	8 35
		Total Dec. 6, 1905 to Dec. 6, 1907	$181 22

DIRECTOR'S ACCOUNT.

1906.				
Jan.	11.	Railroad fares November and December, 1905		$ 4 20
Jan.	11.	Items paid by Director, but carried to other accounts:		
		Nov. 7, 1905, telephone No. 1012, rent Aug., Dec. and Jan. ($3), and tolls, ($2 50), (to office account)	$ 5 50	
		Jan. 9, 1906, P. O. Box rent, quarter ending March 31, (to office account)	1 00	
		Jan. 10, 1906, telephone No. 1012, rent Nov. Dec. and Jan. ($3), and tolls, ($2 50), (to office account)	5 50	
		Jan. 10, 1906 telephone No. 1540, rent quarter ending Mch. 31 (to office account)	6 00	
			$ 18 00	
April	4.	Pay, 14-31 of month (Act of 1906), $11 29 and traveling expenses February and March, $38.87, total		50 16
April	4.	Items paid by Director, but carried to other accounts:		
		Feb. 10, telephone No. 1012, rent for February, $1, and January tolls, $1.45, (to office account)	$ 2 45	
		Mch. 10, telephone No. 1012, rent for Mch., $1, and February tolls, $2.85, (to office account)	3 85	
		April 2, P. O. Box, rent quarter ending June 30, (to office account)	1 00	
		April 3, rent telephone No. 1012, for April, (to office account)	1 00	
		April 3, rent telephone No. 1540, quarter ending June 30, (to office account)	6 00	
			$ 14 30	
April	18.	Traveling expenses in April		57 65
April	18.	Items paid by Director, but carried to other accounts:		
		April 2, paid H. B. Pope, work in office, Oct. 1, 1905 to April 1, 1906, (to office account)	$ 30 00	
		April 9, telegram to Washington, (Wilson) (to office account)	40	
		April 16, telegram to Cincinnati, (Hodge), (to office account)	25	

1906.

		April 17, J. W. Norwood, account fee for Notary Commission, $2, and rubber stamp, 25c, for Survey, (to office account)	$2 25	
			$ 32 90	
May	8.	Pay, for April, $25, and railroad fares April 19 and May 4, $4.90, total		$ 29 90
May	8.	Items paid by Director, carried to other accounts:		
		April 26, telegram, (to office account)	$ 0 39	
		April 30, E. M. Collins, typewriting 5 3-4 days, (to office account)	5 75	
		May 2, telegrams (Milton, Wis., 68c, Big Stone Gap, 40c) (to office account	1 08	
		May 2, telegram from Milton, Wis., (to office account)	68	
		May 2, rent telephone No. 1012, for May, $1 00 and tolls, March and part of April, $0.70, (to office account)	1 70	
		May 5, H. B. Pope, work in office for April, (to office account)	5 00	
		May 5, N. L. English, typewriting 1 1-2 days, (to office account)	1 50	
		May 5, Rhoda Miller, typewriting, 4 1-2 days, (to office account)	4 50	
			$20 60	
June	11.	Pay for May, ($25), and traveling expenses in May ($5.55), total		30 55
June	11.	Items paid by Director, but carried to other accounts:		
		June 2, 8 telegrams, on account of "Co-operation" (to office account)	$4 10	
		June 2, H. B. Pope, work in office, May, (to office account)	5 00	
		June 6, telegram to Washington, (to office account)	55	
		June 8, rent, telephone No. 1012, for June ($1.) and tolls, April 22 to May 22, ($1.) (to office account)	2 00	
			$11 65	
July	3.	Pay for June		$25 00
July	3.	Items paid by Director, but carried to other accounts:		
		June 24, 2 telegrams to Marion, (to office account)	$ 0 54	
		July 2, Jas. Mack, janitor, pay for June, (to office account)	25 00	

1906.				
July	2.	Rent, P. O. Box, for quarter ending Sept. 30, (to office account)	$1 00	
		July 2, rent, telephone No. 1012, for quarter ending Sept. 30, ($3.) and June tolls, ($1.15), (to office account)	4 15	
July	2.	Rent, tel. No. 1540, for quarter ending Sept. 30, (to office account)	6 00	
			$36 69	
Aug.	9.	Pay for July ($25.) and railroad fares for July, ($11.30)		$36 30
Aug.	9.	Items paid by Director, but carried to other accounts:		
		July 5, telegram to Big Stone Gap, (to office account)	$0 46	
		July 6, telegram to Big Stone Gap, (to office account)	67	
		July 11, telegram to Straight Creek, (to office account)	55	
		July 16, telegram from Morganfield, (to office account)	26	
		Aug. 3, telephone tolls for July, (to office account)	80	
			$ 2 74	
Sept.	1.	Pay for August, $25.) and traveling expenses for August, ($1.95), total		26 95
Sept.	1.	Items paid by Director, but carried to other accounts:		
		Aug. 9, telegram to Beaver Dam, (to office account)	$0 45	
		Aug. 13, cash, refunding express charges to State Geologist of Indiana, (to office account)	90	
		Aug. 28, drawing pens, (to office account)	30	
		Aug. 31, telephone tolls for August, (to office account)	50	
			$ 2 15	
Oct.	2.	Pay for September		25 00
Oct.	2.	Items paid by Director, carried to other accounts:		
		Oct. 1, telephone No. 1012, rent, quarter ending Dec. 31, (to office account)	$6 00	
		Oct. 1, telephone No. 1540, rent, quarter ending Dec. 31, (to office account)	6 00	
		Oct. 1, tolls on telephone No. 1540, in June, (to office account)	15	

1906.				
		Oct. 1, P. O. Box rent, quarter ending Dec. 31, (to office account)	$1 00	
		Oct. 1, telegram to Louisville (Sept. 29), (to office account)	51	
			$13 66	
Oct.	30.	Pay for October		$25 00
Oct.	30.	Items paid by Director, carried to other accounts:		
		Oct. 19, paid W. Johnston and helper for moving museum cases, (to museum account)	$0 80	
		Oct. 30, 2 pads for stencil stamps, (to office account)	45	
			$ 1 25	
Nov.	30.	Pay for November, ($25.) and traveling expenses, November, ($11.70), total		36 70
Nov.	30.	Items paid by Director, carried to to other accounts:		
		Nov. 1, 2 telegrams, (to office account)	$0 89	
		Nov. 3, telephone tolls for October, (to office account)	65	
		Nov. 23, telegram to Middlesboro, (to office account)	25	
		Nov. 30, telegram from Big Stone Gap (Nov. 26), (to office account)	40	
		Nov. 30, telephone tolls for November, (to office account)	40	
			$ 2 59	
Dec.	31.	Pay for December, ($25.) and traveling expenses, December, ($3.40), total		$28 40
Dec.	31.	Items paid by Director, carried to other accounts:		
		Dec. 5, telegram to Louisville, (to office account)	$0 25	
		Dec. 26, telegram to Louisville, (to office account)	49	
		Dec. 31, paid telegram to Dayton, Ohio (25c) and telegram to New York, (61c) (to office account)	$0 86	
		Dec. 31, P. O. Box rent, quarter ending Mch. 31, (to office account)	1 50	
			$ 3 10	
1907.				
Feb.	4.	Pay for January ($25.) and railroad fares for January ($1.70), total		$26 70

1907.				
Feb.	4.	Items paid by Director, carried to other accounts:		
		Jan. 19, paid 2 men, 1 day each, for moving cases in museum, (to museum account)---	$3 50	
		Feb. 2, ink pad for office, (to office account)	25	
		Feb. 2, telephone tolls for January, (to office account) ----------	1 90	
			$ 4 65	
Mch.	6.	Pay for February ----------		$25 00
Mch.	6.	Items paid by Director, carried to other accounts:		
		Feb. 16, telegram to Greenville, Ky., (to office account) ----------	$0 65	
		Mch. 1, towel roller bar, (to office account)	10	
		Mch. 1, telephone tolls for February, (to office account) ----------	65	
			$ 1 40	
April	2.	Pay for March ($25.) and railroad fares for March, ($8.20), total ----------		33 20
April	2.	Items paid by Director, carried to another account:		
		Mch. 30, P. O. Box rent, quarter ending June 30, (to office account)----------	$2 00	
			$ 2 00	
May	2.	Pay for April, ($25.) and railroad fares for April, ($1.70), total ----------		26 70
May	2.	Items paid by Director, carried to other accounts:		
		April 30, Postal Telegraph Co., 6 telegrams in April (to office account) ----------	$3 32	
		May 1, Western Union Telegraph Co., 1 telegram in April, (to office account) ---------	25	
			$ 3 57	
June	11.	Pay for May, ($25.) and traveling expenses in May, ($65.05), total ----------		90 05
June	11.	Items paid by Director, carried to other accounts:		
		May 28, paid W. W. Shelby, Jr., for assistance in museum, (to museum account)---	$1 50	
		June 4, paid Western Union Telegraph Co., telegram in May, (to office account) ------	25	
			$ 1 75	
July	4.	Pay for June, ($25.) and railroad fares in June, ($3.40), total ----------		28 40
July	4.	Items paid by Director, carried to other accounts:		
		June 26, P. O. Box rent, quarter ending		

1907.				
		September 30, (to office account)	$2 00	
		July 1, telegrams during June, (to office account)	4 77	
			$ 6 77	
Aug.	17.	Pay for July, ($25.) and traveling expenses in July, ($17.40), total		$42 40
Aug.	17.	Items paid by Director, carried to other accounts:		
		July 30, Western Union Telegraph Co., telegrams in July, (to office account)	$1 88	
		July 30, Brock & Co., tin tube for map, (to equipment account)	1 00	
		July 30, telephone tolls in July, (to office account)	1 50	
		July 30, Mose Holeman, labor in museum, (to museum account)	1 50	
			$ 5 88	
Sept.	3.	Pay for August ($25.)		25 00
Oct.	1.	Pay for September ($25.)		25 00
Oct.	1.	Items paid by Director, carried to other accounts:		
		Aug. 31, Western Union Telegraph Co., telegrams in August, (to office account)	$1 88	
		Sept. 1, East Tennessee Telephone Co., telephone tolls in August, (to office account)	95	
		Sept. 27, P. O. Box rent. for quarter ending December 31, (to office account)	2 00	
			$ 4 83	
Oct.	18.	Traveling expenses in October, as per Auditor's book		31 37
Oct.	18.	Items paid by Director, but carried to other accounts:		
		Oct. 4, 2 boxes for shipping books, (to office account)	$0 20	
		Oct. 4, hauling boxes to office, (to office account)	25	
		Oct. 4, telephone message in Sept., (to office account	25	
			$ 0 70	
Nov.	8.	Pay for October		25 00
Nov.	8.	Items paid by Director, carried to other accounts:		
		Oct. 30, telegram to U. S. Geo. Survey, Washington, D. C. (to office account)	$0 56	
		Nov. 1, T. B. Hay & Co., repairing tape line (to Gen. Equip. and Repairs)	50	

1907.				
		Nov. 5, East Tennessee Telephone Co., tolls for October, (to office account)	2 55	
		Nov. 5, Western Union Telegraph Co., telegrams in October, (to office account)	1 56	
			$ 5 17	
Dec.	6.	Pay for November, ($25.) and traveling expenses in November, ($6.20)		$31 20
Dec.	6.	Items paid by Director, carried to other accounts: Dec. 4, telephone tolls in November, (to office account)	$0 25	
			$ 0 25	
		Total field expenses and pay, Dec. 6, 1905, to Dec. 6, 1907		**$785 83**
		Total items paid and carried to other accounts, Dec. 6, 1905, to Dec. 6, 1907	$196 60	

TOPOGRAPHIC MAPPING IN CO-OPERATION WITH U. S. GEOLOGICAL SURVEY.

1906.			
May	8.	C. H. Semper, expenses for April	$ 75 09
May	31.	L. E. Tucker, expenses May 10-17, $13.05, and May 6-16, $26.55	39 60
May	31.	R. W. Berry, pay roll for May	282 49
May	31.	L. S .Smith, pay roll for May	197 33
May	31.	C. H. Semper, levelman, pay for May	100 00
June	4.	J. R. Ellis, pay roll for May	98 83
June	4.	J. R. Ellis, pay for 5 days in May	16 67
June	16.	L. S. Smith, expenses May 8-31, $303.16, and May 10, 11, 19, $4.15	307 31
June	16.	Scott & Scott, livery for L. S. Smith in May	36 00
June	16.	G. D. Wilson, livery for L. S. Smith in May	45 00
June	16.	R. W. Berry, expenses in May	80 67
June	16.	Capital Hotel, (Morganfield), subsistence of R. W. Berry and party, in May	273 00
June	16.	Cambron & Clements, livery for R. W. Berry in May	22 45
June	16.	J. C. D. Hapgood, livery for R. W. Berry party in May	100 50
June	16.	J. R. Ellis, expenses May 10 to 17	78 02
June	16.	W. J. Lloyd, expenses May 26 to 28, $33.40, and subsistence, May 28 to 31, $5.25	38 65
June	19.	J. R. Ellis, services 16 days, $53.33 and expenses in May, $160.15	213 48
June	19.	Geo. T. Hawkins, pay for June, 1-2 month	91 67

1906.			
July	6.	E.L.McNair,pay and subsistence roll for June	$157 00
July	6.	L. S. Smith, pay and subsistence roll for June	605 00
July	6.	Phoenix Hotel, L. S. Smith's board, 11 days in June	27 50
July	6.	G. D. Wilson, livery for L. S. Smith in June	30 00
July	13.	J. R. Ellis, pay and subsistence roll for June	355 00
July	13.	R. W. Berry, pay and subsistence roll for June	735 00
July	13.	R. W. Berry, miscellaneous expenses in June	98 95
July	18.	L. S. Smith, field and miscellaneous expenses in June	90 96
July	18.	J. R. Ellis,' per diem subsistence and miscellaneous expenses in June	186 00
July	18.	W. H. Williams & Son, livery for McNair in June	40 50
July	18.	Cambron & Clements, livery for Berry party in June	73 50
July	18.	W. J. Greenwell, board of W. J. Lloyd in June	45 00
July	18.	W. M. Payne, livery for Berry party in June	39 75
July	18.	A. L. Grady, livery for Berry party in June	22 75
July	18.	Ashby Bros., livery for Berry party in June	43 50
July	18.	J. C. D. Hapgood, livery for Berry party in June	31 00
July	18.	W. J. Greenwell & Co., board of R. W. Berry in June	36 00
July	18.	W. J. Waller, pay as rodman, 4 days in June	4 00
July	18.	Cambron & Clements, livery for W. J. Lloyd in June	34 50
July	18.	J. J. Watkins, livery for Berry party in June	13 50
July	18.	E. L. McNair, per diem subsistence and miscellaneous expenses in June	166 16
Aug.	6.	R. W. Berry, pay and subsistence roll for July	648 00
Aug.	14.	J. H. Clinton, subsistence of R. W. Berry, (5 days) and L. B. Pride (3 1-4 days) in July	12 37
Aug.	14.	D. Y. Combs, feed for horses used by E. L. McNair and party, 26 feeds in July	13 00
Aug.	14.	J. R. Sowders, livery for R. W. Berry and E. E. Barton in July	24 00
Aug.	14.	A. L. Grady, livery for R. W. Berry, and E. L. Keenan, in July	42 00
Aug.	14.	W. M. Payne, livery for R. W. Berry and party in July	55 50
Aug.	14.	Fowler Stafford, livery for W. H. Sallee Sidney Jenkins, F. H. West and J. O. Sallee in July	76 12
Aug.	14.	Scott & Scott, livery for L. S. Smith and party in July	137 00
Aug.	14.	E. L. McNair, pay and subsistence roll for July	94 25
Aug.	14.	L. B. Pride, 6 days in July as rodman in R. W. Berry's party	6 00
Aug.	14.	W. N. Morrill, pay and subsistence roll for July	419 50
Sept.	3.	W. P. Dudley, pay and subsistence per diem, (E. L. McNair party) for August	$ 84 25
Sept.	3.	G. K. Chapman, pay and subsistence per diem (L. S. Smith party) for August	96 50
Sept.	3.	R. W. Berry, pay and subsistence per diem roll for August	468 67

1906.			
Sept.	8.	E. L. McNair, subsistence per diem and miscellaneous expenses for August	$153 80
Sept.	8.	W. N. Morrill, pay and subsistence per diem roll for August	514 00
Sept.	8.	L. S. Smith, pay and subsistence per diem roll for July	102 00
Sept.	8.	G. W. Moscow, livery for G. K. Chapman, (L. S. Smith party), 12 days in August	18 00
Sept.	8.	Scott & Scott, livery for L. S. Smith (4 days) and G. K. Chapman, (15 days) in August	58 00
Sept.	8.	W. D. Wallingford, livery for R. P. Thompson, 3 2-3 days in August	5 50
Sept.	8.	Tom Williamson, livery and driver for E. L. McNair, 31 days of August	117 80
Sept.	15.	W. H. Sallee, expenses July 2 to August 31	25 05
Sept.	15.	I. Sidney Jenkins, expenses July 6 to August 31	13 22
Sept.	15.	W. N. Morrill, subsistence per diem and miscellaneous expenses, 21 days in August	71 33
Sept.	15.	W. M. Payne, livery for R. W. Berry and party in August	85 00
Sept.	15.	J. J. Watkins, livery for E. E. Barton (Berry party) 4 days in July	6 00
Sept.	15.	A. O. Burkland, subsistence per diem and miscellaneous expenses in August	89 98
Sept.	15.	J. O. Sallee, miscellaneous expenses July 19 to August 29	20 36
Sept.	15.	A. L. Grady, livery for R. W. Berry and party in Aug.	68 25
Sept.	15.	Fowler Stafford, livery for W. H. Sallee, Sidney Jenkins & J. O. Sallee (W. N. Morrill party) in August	107 75
Sept.	15.	S. Ragan & Son, livery for W. N. Morrill and A. O. Burkland in August	55 25
Oct.	2.	R. W. Berry, pay and subsistence per diem roll for September	106 67
Oct.	2.	G. K. Chapman, (L. S Smith party) pay & subsistence per diem, 4 days in Sept.	12 67
Oct.	2.	A. L. Grady, livery for R. W. Berry & Party in Sept.	39 00
Oct.	2.	L. H. N. Salyer, livery for E. L. McNair and W. P. Grady, in September	17 25
Oct.	2.	R. W. Berry, subsistance per diem and miscellaneous expenses in September	93 80
Oct.	9.	W. N. Morrill, pay & subsistence roll (Sallee & others) for September	162 30
Oct.	9.	E. L. McNair, (Dudley, field assistant) pay & subsistence roll for September	82 50
Oct.	9.	Amos L. Lindsay, pay as "laborer" for W. H. Monahan, 12 days in September	30 00

1906.			
Oct.	9.	W. H. Monahan, Field Assistant, (Levels from Lexington to Jackson), 20 days in Sept.	$159 60
Oct.	9.	L. S. Smith, Top Aid, traveling & per diem expenses in September	93 10
Oct.	9.	Tom Williamson, livery & driver for E. L. McNair, 28 days in September	106 40
Oct.	9.	Scott & Scott, livery for L. S. Smith, 18 days in Sept.	36 00
Oct.	30.	L. S. Smith, pay and per diem roll (for F. P. Hoover & O. B. Howard), for August	62 33
Nov.	10.	A. L. Lindsay, (with W. H. Monahan), pay, 2 days in Oct.	5 00
Nov. 1907	10.	W. N. Morrill, subsistence per diem & miscellaneous expenses in October	105 91
June	11.	C. B. Kendall, traveling expenses, May 27, 28, 29	25 20
July	31.	C. B. Kendall, pay & subsistence roll, (C. W. Renshaw & others), for July	168 33
July	31.	T. H. Stone, hire of team, 2 horses & three seated hack, for C. B. Kendall, Field Ass't., for use in transporting primary traverse party to and from work in vicinity of Hartford, Ky., July 1 to 10, inclusive	30 00
Aug	17.	A. O. Burkland, pay & subsistance roll, (R. E. Johnson & 3 others), for July	396 00
Aug.	17.	A. O. Burkland, pay & subsistence roll, (Spencer Smith & 7 others), for July	752 50
Aug.	17.	L. B. McCarty, livery for field work on the Whitesville, Ky. sheet, under direction of C. C. Gardner, Jr. Topgr., (Gardner & party), in July	130 50
		and, hire of single horse & buggy for F. H. Moncure, Topg. Aid, for work on Whitesville, Ky. sheet, 10 days in July	20 00
Aug.	17.	W. T. Hamell, livery for S. C. Smith, traversemen, July 25 to 31, inclusive, & for W. H. Sallee, traverseman, July 25 to 31, inclusive & ½ day on 24th	15 75
Aug.	17.	T. M. Baker, livery for A. O. Burkland, R. E. Johnson, W. H. Sallee, & G. W. Crane, in July	70 75
Aug.	17.	W. J. Barnhill, livery for A. O. Burkland, J. A. Lilly, R. E. Johnson, W. H. Sallee, & G. L. Hayman, in July	63 00
Aug.	17.	A. O. Burkland, traveling & miscellaneous expenses for expenses for self & party, in July	28 09
Aug.	17.	O. A. Burkland, traveling & miscellaneous expenses for self & partq, in July	17 62
Aug.	17.	A. O. Burkland, traveling & miscellaneous expenses for self & party, $69.75, and subsistence per diem, $19,14, in July	88 89

1907.

Aug. 17.	W. A. Smith, livery for A. O. Burkland, R. E. Johnson, J. A. Lilly, in July	$14 00
Aug. 22.	T. H. Moncure, miscellaneous field expenses in July	21 55
Sept. 3.	W. A. Smith, livery for A. O. Burkland and party in July	118 00
Sept. 3.	W. T. Howell, livery for S. C. Smith and W. H. Sallee, in July	39 00
Sept. 17.	A. O. Burkland, pay & subsistence roll, (W. H. Sallee & Spencer Smith), for Aug.	218 00
Sept. 17.	A. O. Burkland, pay & subsistence roll, (R. E. Johnson and 7 others), for August	757 50
Sept. 17.	T. H. Moncure, pay & subsistence roll, (B. B. Barton & 2 others), for August	175 50
Sept. 17.	C. E. Barnett, livery for R. L. Harrison, Topog. Aid, 11 days in August	19 25
Sept. 17.	C. C. Gardner, Jr. Topog., miscellaneous expenses, August 12 to August 22	4 00
Sept. 17.	L. B. McCarty, livery for C. C. Gardner, Jr. Topog. for field work on Whitesville, Ky., quadrangle, single horse & buggy, in August	41 00
Sept. 17.	A. O. Burkland, Ass't. Topog., expenses and subsistence per diem for self & party in Aug.	167 27
Sept. 17.	W. T. Howell, livery for W. H. Sallee and S. C. Smith, in August	40 50
Sept. 17.	L. B. McCarty, livery for T. H. Moncure, in Aug. and B. B. Barton, 1 day & part of 1 day, in Aug.	57 00
Sept. 17.	T. H. Moncure, traveling & miscellaneous expenses, in August	28 58
Sept. 17.	W. A. Smith, livery for A. O. Burkland, R. E. Johnson & G. L. Hayman, in August	41 75
Sept. 17.	Robt. Crow, livery for J. A. Lilly, G. W. Crane & R. L. Harrison, in August	43 75
Oct. 12.	H. B. Spencer, livery for A. O. Burkland and R. E. Johnson, in September	47 25
Oct. 12.	A. O. Burkland, pay & subsistence roll, (W. H. Sallee & 12 others), for August	1,099 46
Oct. 12.	Barnett & Crow, livery for A. O. Burkland and 5 others, in September	127 50
Oct. 12.	L. B. McCarty, livery for T. H. Moncure, in September	46 50
Oct. 12.	T. H. Moncure, traveling & miscellaneous expenses, for September	11 59
Oct. 12.	C. C. Gardner, traveling & miscellaneous expenses, for Setember	17 29
Oct. 12.	R. L. Harrison, miscellaneous expenses and subsistence per diem for Sept.	68 55

1907.			
Oct.	12.	L. B. McCarty, livery for C. C. Gardner & B. B. Barton, for work on Whitesville quadrangle, for September	$43 25
Oct.	18.	Oscar Stevens, livery for R. E. Johnson, J. A. Lilly & G. W. Crane, in September	54 25
Oct.	18.	A. O. Burkland, traveling expenses and subsistence per diem for September	203 00
Oct.	21.	Barnett & Crow, livery for R. L. Harrison, (3½ days), & for G. L. Hayman, (1 day), in Oct.	10 12
Oct.	21.	W. T. Howell, livery for B. B. Barton, 15 days, and for Spencer Smith, 26 days, in Sept.	61 50
Nov.	9.	R. L. Harrison, traveling & miscellaneous expenses, for October	22 91
Nov.	9.	R. L. Harrison, subsistence per diem, for Oct.	62 00
Nov.	9.	L. B. McCarty, livery for T. H. Moncure, 27 days in October	54 00
Nov.	9.	L. B. McCarty, livery for C. C. Gardner, (work on Whitesville quadrangle), 28½ days in Oct.	57 25
Nov.	9.	S. D. Groves, livery for J. M. Dyer, levelman, Sept. 23 to Oct. 24, inclusive	26 66
Nov.	9.	O. B. James, (Centertown), livery for A. O. Burkland, 13 days in October	19 50
Nov.	9.	A. O. Burkland, pay & subsistence roll, (R. E. Johnson & 14 others), for October	1,100 71
Nov.	15.	T. H. Moncure, traveling & miscellaneous field expenses in October	20 21
Nov.	15.	C. C. Gardner, Jr. Topog., traveling and miscellaneous field expenses in October	9 10
Nov.	15.	Oscar Stevens (Beaver Dam), livery for R. W. Berry, R. E. Johnson, J. A. Lilly, & transportation for H. W. Peabody and rodman, in October	56 00
Nov.	15.	A. O. Burkland, subsistence per diem and traveling expenses, in October	228 17
Dec.	6.	L. B. McCarty, (Whitesville), hire of single horse & buggy, T. H. Moncure, 7 days in Nov.	14 00
Dec.	6.	Ross L. Bennett (Rockport), to feed & care of one public animal, 28 feeds, $7; to feed & care of one Survey animal, 10 feeds, $2 50, and hire of one horse for Survey use, 1 day, Nov. 7, $1 25	10 75
Dec.	6.	Oscar Stevens, (Beaver Dam), livery for R. W. Berry, 13 days, R. E. Johnson, 14 days & A. O. Burkland, 8 days, in November	61 25
Dec.	6.	A. O. Burkland, pay & subsistence roll, (R. E. Johnson & 10 others), for November	562 34
		Total, December 6, 1905, to December 6, 1907	$17,421 70

EXCHANG

Kentucky Geological Survey

CHARLES J. NORWOOD, Director.

REPORT

ON THE

Progress of the Survey

FOR THE YEARS 1908 AND 1909.

By CHARLES J. NORWOOD.

LEXINGTON, KENTUCKY.

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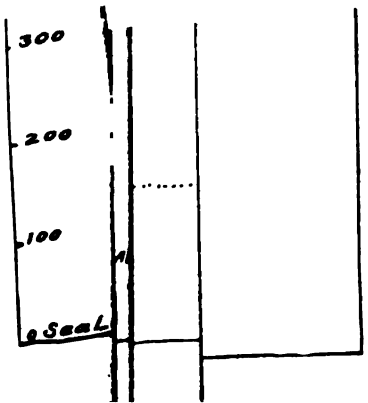

LETTER OF SUBMITTAL

To His Excellency, AUGUSTUS E. WILLSON,
Governor of Kentucky.

Sir: I have the honor to submit the following report on the progress of the Geological Survey for the calendar years 1908 and 1909, for your consideration and for transmittal to the General Assembly. Very respectfully,

CHARLES J. NORWOOD,
Director, Kentucky Geological Survey.

January 31, 1910.

PERSONNEL OF THE SURVEY

The following persons now hold or have held positions on the Survey during the period covered by this report. They are named in the order of their appointment under each class

Director.—Charles J. Norwood.

Assistants in Geology.—Joseph B. Hoeing (also Cartographer), until April, 1908. Mr. Hoeing found it necessary to withdraw because of ill health. Arthur M. Miller, until July 1909. Aug. F. Foerste, Albert R. Crandall, F. Julius Fohs, James, M. Hodge, (until March, 1909,) William C. Morse (parts of 1908 and 1909), Leonidas C. Glenn, and F. M. Hutchinson.

Chemistry, Technology, and Soils.—Alfred M. Peter, supervising chemist and in charge of soil testing; Harry D. Easton, assistant in clay testing; James H. McHargue, chemist; Sadocia C. Jones, assistant in soils; and Ralph D. Quickel, aid in fuel testing.

Office.—F. Grider McKay, clerk; Nancy D. Bentley, stenographer; Joseph W. Norwood, draftsman.

Temporary Aids.—T. C. Carroll, field aid in 1908. Page B. Blakemore, in chemical laboratory, part of 1908. Robert G. Stevens, aid in collecting statistics (in co-operation with the U. S. Geological Survey) and in Museum. Kessack D. White and W. Bruce Hager, field aids, season of 1909.

Other persons have been employed occasionally, but only for brief periods.

In the co-operative topographic mapping large field parties, under the direction of topographers of the U. S. Geological Survey, were employed. It is not deemed necessary to give the long list of names here.

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REPORT OF PROGRESS

The scope of the operations of the Geological Survey is indicated by the following provisions, set forth in section five of the Act of 1908: "It shall be the duty of the director of the Survey and his assistants to examine and report upon the economic geology of the State especially, as specified in and in accordance with section five of Chapter 19, Acts of the General Assembly of 1904, said investigations to be conducted along such lines as will prove of practical value in ascertaining and exhibiting the fitness for commercial uses of the various substances reported upon, and to include such standard and practical tests as are necessary and usual in determining the commercial values of the various materials under investigation; and in furtherance of such practical work, the director, should he deem it advisable, is autl. .ized to purchase or lease a drilling machine for use in prospecting regions where the existence or continuation of coals, ores or other useful substances beneath the surface may not be readily determined in any other way, or to make such other arrangements for borings as may appear most feasible and economical. The underground and surface waters of the State shall be investigated, and the director is authorized, should he deem it expedient, to co-operate with the State Forestry Commission in the study of the timbers of the State. Especial attention shall be given to the study of the soils of the State, with reference to their conservation and their fitness for various classes of crops, with a view of determining the proper fertilizers for impoverished or otherwise defective lands, and such results as are appropriate shall be embodied in a soil map; and to the end that the soil investigations may be most effectively carried on, the director is authorized to continue the agreement with the director of the State Agricultural Experiment Station, en-

tered into under authority of Chapter 49 of the Acts of the General Assembly of 1906, for co-operation and assistance in the work. An investigation of road materials shall also be carried on, and such tests be made as come within the means of the Survey, with a view to determining the availability of materials in the various counties of the State for road building, and the best methods of preparing them for local application, and the results shall be embodied in a special bulletin; and the director is authorized to enter into an agreement with such bureau of the Federal Government as may be proper for co-operation in this work. As a contribution toward a better knowledge of the requirements for the safe working of the mines of the State, the technological work of the Survey shall include an investigation of the mine gases and coal dusts and of such other matters as are appropriate, to such extent as the means of the Survey may permit."

It is also provided that, "The reports of the Survey shall consist of subject reports, county reports, miscellaneous bulletins, and a general or index report, accompanied by all diagrams, maps and illustrations necessary to render them full and complete."

The section of the Act of 1904 referred to requires the Survey to give "particular attention to such mineral resources as coal, iron, lead, zinc, barite, fluorite, clays, shales, building stones, asphalt rock, road and paving materials, natural fertilizers, petroleum, natural gas, pigment earths, abrasives, marbles, lithographic stones, and other minerals; determining their location and extent, which shall be shown on appropriate diagrams and maps, their relations to transportation routes, actual and possible, and their chemical and physical qualities to such extent as may be necessary in each case."

The first work of the Survey, under the law and because of conditions that had prevailed for twelve years during which nothing was done by the State to determine our own resources, while Surveys were continuously in operation in, so to speak, rival States, had to be general—dealing with the mineral and other natural resources of the State by subjects. This has carried the Survey into a larger number of counties within a limited time than otherwise would have been the case, and

has been of greater advantage to the Commonwealth as a whole than had reports on particular, restricted areas (such as counties) been the first to be undertaken. A large field has been covered by this general examination, which is bearing fruit in the notable development of the State which is now going on along various lines. As recently stated in an article for the press, it seems quite within bounds to say that the re-establishment of the Geological Survey, immediately following the mineral exhibit made at the St. Louis World's Fair, has resulted in bringing more active capital into the State, and has done more to forward development of lands that hitherto had contributed little to the State treasury, within the last six years, than could otherwise have been accomplished in thrice that period.

Printing of Reports.

Unfortunately, the printing of completed reports has not kept pace with their preparation, and this has resulted in embarrassments for the Survey in various ways. Among other things, it has placed a heavy tax on the time of the Director, in necessitating the preparation of abstracts from reports, completed but unavailable for distribution because unprinted, concerning regions about which inquiries have been received; and this has prevented his keeping abreast of the large general correspondence of the office.

The following reports are now in the hands of the printer, and have been for many months: No. 10, Coals of the Licking Valley and of some of the Contiguous Territory;* No. 11, Coals of the Three Forks of the Kentucky River;* No. 13, Coals of the Western Border of the Eastern Coalfield;* No. 14, Coals of the Pineville Gap Region; No. 15, The Cincinnatian Formation and Its Economic Values; No. 16, General Report on the Lead, Zinc, and Spar Districts of Western Kentucky, (embracing Caldwell, Christian, Crittenden, Livingston, Lyon, and Trigg counties); and a revision of a report on

*This report is in type, and has been for some time.

the natural resources of Livingston county, found in manuscript among the archives of the Survey.

The following reports have been ready for the printer for many months, but have been held in the office until the reports which had been turned over to him should be received: (a) On the Resources of Breckenridge and Meade Counties, being a revision (in accordance with later field investigations) of reports prepared some years ago; (b) Mining Thin Coal Seams; (c) Key to the State Geological Map. A report on the Coals of the Western Field, which had been prepared, has been withheld in order that advantage may be had of the mapping which has been carried on in that field during recent years; other and more satisfactory reports, two of which are in preparation and should be ready for printing by next May or June, will be substittued for it.

Eleven reports, ready for the printer or in course of preparation, will be noted under appropriate headings. Abstracts from eight of them are given in this report, in order that present needs may to some extent be satisfied.

The Coal Fields.

Coals of the Tug Fork in Martin and Pike Counties.—One of the most important contributions toward an understanding of the coals in the important region bordering the Tug Fork of the Big Sandy is the report of Prof. A. R. Crandall, based on field work carried on in 1909, of which a summary is given in this report; it will be found quite helpful, not only to engineers engaged in the field included in the Tug drainage, but to all who are interested in other portions of the Big Sandy Valley. Among the important features of the report, especially to investors who are familiar with West Virginia names, are the correlations of the seams, now given for the first time. According to Prof. Crandall, equivalencies are as follows:

No. 1, (*according to the old nomenclature*).—This is the Warfield, of Martin county; the Paintsville, and the Millers Creek Block, of Johnson; the Prestonburg, of Floyd; the Burnwell, Freeburn, Vulcan, and Majestic seams of the Tug

Fork; and the Lower Elkhorn of the Levisa and Russell Forks. It correlates with the Warfield, No. 2 Gas, and Rowl, of West Virginia. Hitherto, the Lower Elkhorn, the excellence of which for coking was first brought to public attention by the Kentucky Survey some years ago, has been regarded as No. 3.

No. 3 (*of the old nomenclature*).—This is the Peach Orchard seam of Levisa Fork; the Alma (?) of Tug Fork; and the Alma, Peerless, and Mate Creek, of West Virginia.

No. 5 (*old nomenclature*).—This is the Upper Elkhorn of Levisa and Russell Forks; the Watson, Webb, Young, and Cherokee, of Lawrence county; the Broas Block, of Martin; and the Tracker of the Tug region in Pike. It is the Thacker, Glenalum, and Red Jacket, of West Virginia.

No. 8 (*old nomenclature*).—This is the "8-foot coal," and the Broas F. Coal, of Martin county; the Borderland coal of the Tug Fork region; and the Winifred of West Virginia and of the Borderland district in Kentucky.

The War Eagle coals of West Virginia are represented by the Elswick and Anxious creek coals of Russell and Levisa Forks in Kentucky.

Additions to the Licking Valley Report.—The delay in printing the report on the coals of the Licking Valley has not, as regards ultimate results, been without its compensations. It permitted Prof. Crandall, as the result of field work in 1908, to add materially to its value with respect to the occurrence and qualities of cannel beds in that region. It also permitted him to make revisions and additions to the Elliott county report, with respect to coals and the peridotite dikes—the latter having been the subject of much speculation and exploitation as sources of diamonds. It may be remarked here that, so far as authentic information discloses, no diamonds have been found in the dikes.

Coals of the Green River Drainage.—During the season of 1909, Mr. F. M. Hutchinson was engaged in a study of the coals of part of the region in the Green river drainage, in the Western Coalfield. Accurate work was rendered possible by the completion of the mapping of several quadrangles in that portion of the field, by the U. S. Geological Survey and the Kentucky Geological Survey acting in co-operation. Mr. Hutch-

inson was instructed to determine the number of coal beds, the average thickness, quality, dip, depth underground, and minable values of each bed, and to map, in sufficient detail for practical purposes, the areas in outcrop and below drainage of the several seams; to collect samples for analysis and for the determination of heating values, and to gather such general information as is of interest alike to the present owner and to the prospective purchaser or lessee. The quadrangles selected for the season's work were the Central City, Madisonville, Calhoun, and Newberg, embracing portions of Henderson, Daviess, Webster, McLean, Hopkins, Muhlenberg, and Ohio counties, and including an area of about 800 square miles. In addition to plotting on the topographic maps all the mines and country banks of which knowledge could be obtained, and of a large number of outcrops of coal and of other strata that may serve as "key-rocks" for the engineer employed in development work, spirit-level lines were run to each important geologic location for the determination of the average dip for each locality. The results of the season's work were very satisfactory, indeed, and have cleared up some problems in the field that have hitherto been troublesome. One of the most important results of Mr. Hutchinson's work is the definite tracing of the No. 9 coal (the most important coal, commercially, in the Western Field) across the Rough Creek Uplift, from the South to the Ohio river. The determination of considerable areas of thick coal above No. 12 is another important result, and has added materially to the value of the region for mining purposes. A summary report of the results is given in this report; the detailed report should be ready for the printer by next June.

Coals of the Tradewater Drainage, Western Field.—The study of the coals of this difficult region was placed in the hands of Dr. L. C. Glenn. Because of the many small faults, which are usually masked by the results of the erosion of the soft sandstones and shales, this region has been little understood, and the Survey has been fortunate in securing the services of Dr. Glenn, one of the most capable of geologists, for work in this field. The area embraced in Dr. Glenn's examinations covers about 500 square miles. Dr. Glenn reports that

he, also, succeeded in obtaining a connection between the coals on the south and on the north of the Rough Creek Uplift, though his determinations, in that respect, rest chiefly on drill records north of the uplift. It was not possible to prepare a summary report in time for this report; it is expected that at least a preliminary report will be ready for printing by next May or June.

Mapping Outcrop Lines in the Eastern Field.—The most needed work in the Eastern Field now is the deliniation of the outcrop lines of the mort important coals, and it is very much needed. In order that this may be done, however, more accurate topographic maps of the quadrangles included in that Field than now exist must be made. This map-work has been taken up, as part of the mapping in co-operation with the U. S. Geological Survey, and considerable progress has been made in the necessary triangulation and related work required in order to obtain "control" of the areas. Since the more precise mapping must, in the interest not only of economy but of proper methods, be carried systematically across the Field, the work has begun at the West Virginia border, the West Virginia Survey co-operating in the mapping of quadrangles that lie partly in that State and partly in Kentucky.

Oil and Natural Gas.

The widespread interest in the occurence of petroleum and natural gas in Kentucky is witnessed by the near exhaustion of the preliminary report on our oil and gas sands (Bulletin No. 1), issued in 1905. At the time the bulletin was issued, it was expected that the author, Mr. J. B. Hoeing, would continue in charge of the investigations and extend the work over all parts of the State which seemed to invite examination; but ill health intervened (finally resulting in Mr. Hoeing's withdrawal from the Survey), and, save for miscellaneous notes gathered by various members of the Survey, incidental to other investigations, field work was suspended until the past year.

In Meade and Breckenridge Counties.—Interest in the oil and gas possibilities of Meade and Breckenridge counties hav-

ing been renewed in a very marked way during the past two years, not only by residents of this State but by oil men of other States, Prof. Aug. F. Foerste was assigned to the study of the structural conditions presented by those counties with especial reference to petroleum and gas. An abstract of his report is given in this report, and it is hoped that the full report may be ready for the printer by the middle of the year; it is possible that some additional field work will be necessary, to include regions adjacent to the counties named, before a full report can be made.

In the Western Coalfield.—This is an almost virgin field for the oil and gas driller; a number of wells have been drilled here and there, but in the main they have been placed at ill-chosen points and results have been discouraging to those interested. In order to pioneer the way for drilling in an intelligent fashion in the Field, a study of the structure with reference to oil and gas was included in the work assigned to Mr. Hutchinson, the purpose being to continue the study over all parts of the Field, and to adjacent regions South, East, and West, as the work of the Survey progresses. Mr. Hutchinson is well fitted for such work within the coalfields, having been trained under one of the most accomplished geologists making a specialty of petroleum and natural gas investigations. A brief statement concerning his work during the past season is given in this report; it was not practicable for him to prepare a more comprehensive one.

In the Eastern Coalfield and South-Central District.—Work done in recent years by members of the U. S. Geological Survey and others in the oil fields of Pennsylvania, West Virginia, and Ohio has verified the observations of White, Griswold, and others that oil and gas pools may occur either along the crests or the sides of anticlines, or near the bottoms of synclines, according to local conditions, and that when the habit of accumulation in any particular sand of a given region has been determined the most likely place at which pools may be found in untested areas of that sand may be selected with a fair degree of certainty; but, in addition, it has been found that some producing sands of a given field may not show this tendency towards a definite "habit," and that in such areas the work of

the geologist in selecting places for testing is of little avail, "wild-cat" drilling being practically the only recourse. There are many oil horizons in Kentucky.* Manifestly, it is of great importance that the characteristics of the respective sands shall be known, and that underground mapping of oil-bearing beds in areas where but few test wells have been drilled, done in advance of developed pools that show close structural grouping, can be made of great value to producers in their search for new fields. In 1907 this Survey began underground mapping in Allen, Barren, Simpson, Warren, and Cumberland counties, but in consequence of the ill health of Mr. Hoeing, under whose immediate supervision the work had been placed, and of difficulties encountered in the effort to obtain the services of some other competent man, the mapping was suspended and such results as had been obtained await interpretation. It was with satisfaction, therefore, that an offer for co-operation in such work was received from the U. S. Geological Survey, during the past year. An allotment of $300.00, to be met by a like amount from the Federal Survey, was made for such co-operative work, and Mr. M. J. Munn, of the U. S. Geological Survey, has had supervision of the field work and will prepare the report thereon in connection with a general summary report on the oil and gas fields of the Appalachian region undertaken by the Federal organization. The oil producing areas selected for study include the Campton field of Wolfe county, and the Steubenville, Johnson Fork, Cooper, Oil Valley, and Bachelor Hollow pools of Wayne county. It is hoped that the results may justify further co-operation, and that through such arrangement similar work may be extended to other areas. Further, that the work will pave the way for a broader and more accurate application by producers of the geological principles involved in oil and gas accumulation, resulting in a corresponding reduction of the risks which, at best, must accompany the development of the great oil and gas resources of the State. Undoubtedly, if successful geological work is made possible, it will be the means of preventing the

*See Bulletin No. 1, Ky. Geological Survey, 1904.

loss of thousands of dollars in future drilling; it will obviate the necessity of drilling hundreds of useless holes, and at the same time will admit of a more thorough testing of the best oil and gas regions. Mr. Munn's summary of his work is presented elsewhere in this report.

Barytes, Calcite Lead, and Zinc.

One of the most important minerals of the State is barytes, not only with respect to commercial values but with respect to quantity. In Central Kentucky we have a district richer in such deposits of high quality than may be found, perhaps, in any other State. And yet the Kentucky deposits were so little known, before the efforts of the State Geological Survey within recent years began to bear fruit, that in accounts of barytes deposits in the United States given in technical publications, this State was no more than mentioned, if mentional at all. While the principal consumption of the mineral is for paints—and not simply as an adulterant, as some suppose, but as a useful, honest ingredient—it is used for many other purposes, among them being, glass-making, dressing for asphalt streets, rope filling, imitation marble, filler for rubber goods, porcelain and pottery enamels, enameling for papers and cardboard, the manufacture of lithophone and thus in the manufacture of oil cloths, linoleum, and rubber tires; in the form of barium hydrate for the clarification of sugar and the purification of water; in the manufacture of some of the compounds for the prevention of boiler incrustation; and so on.

Calcite is also used for a number of purposes, including the manufacture of putty and as an important ingredient of paints, the finely ground calcite (known as "whiting") being used to neutralize the acid fats in the oil in which the paint materials are mixed. One of the formulas for "white lead" calls for 10 per cent. "whiting" and 30 per cent. barytes, the remainder being made up of equal parts of lead and zinc. Considerable deposits of calcite occur in the State, one of the most notable being in Mercer county.

Accompanying barytes are galena and zinc blende, though in such minor amount that they can be produced, as a rule,

only as by-products in the mining and treatment of the barytes.

While barytes occurs to some extent in the Western fluorspar district, and in some of the south-central counties, the principal and by far the most important deposits lie within what is known as the Bluegrass Region, and since they occur in nearly vertical veins, as a rule, of which there is a surprisingly large number, they may be worked without permanent detriment to the lands, and without material temporary interference with farming operations.

The geology of the barytes-bearing rocks in Central Kentucky was reported upon by Prof. A. M. Miller, (Bulletin No. 2), and general examinations of many of the veins have been made by Mr. J. E. Wright and by the present writer;* but the detailed examination of the deposits, together with those of calcite, has been made by Mr. F. Julius Fohs, whose report is in course of preparation. Having been absent from the State on leave for the latter third of the past year, it was impracticable for him to prepare an adequate summary of his results for this report, but a brief statement is given elsewhere which will prove of interest to producers and consumers of the minerals named. It will be noted that Mr. Fohs's investigations have carried him over a large number of counties.

Waverly Formations.

Field work in the Waverly formations on the Eastern flank of the Cincinnati uplift was carried on by Mr. W. C. Morse and Prof. A. F. Foerste, in 1908, and a report was made ready for the printer in 1909. The area covered includes parts of Lewis, Greenup, Fleming, Rowan, Carter, Bath, Menefee, Morgan, Montgomery, Clark, Powell, and Estill counties. The economic values described in the report include building stones, of which the "Buena Vista" sandstone is a fine example, shales for brick, tile, and portland cement, and oil and gas horizons. Shales for common brick, drain tile, the better grades of face brick and of paving brick, roofing tile, etc., are

*See First and Second Reports of Progress.

described, and attention called to the usefulness of the black Sunbury and Devonian shales for the manufacture of cement. Samples of typical soils were collected.

Soil Survey.

This work is being carried on in co-operation with the State Agricultural Experiment Station. That portion of the investigation which has to do with the field work (including the collection of soils, the mapping and determination of the geological formations producing the soils in areas examined), with soil physics, and with fertility (pot culture) is cared for by the Survey, while the Experiment Station furnishes the soil-fertility greenhouse, the laboratories (for this work), and the soil chemists. The work is under the immediate guidance of Dr. Alfred M. Peter. So far, the burden of the Survey's part of the investigations (other than the mapping and geology) have been borne by Mr. S. C. Jone, whose practical experience, scientific training, and enthusiastic interest in his work render him peculiarly fitted for his duties. The soil survey is considered a most important part of the Survery's work, and in addition to what has been said in the bi-ennial report for 1906-'07, the following account of the methods followed (from the pen of Mr. Jones) is given: "The field operations consist of noting the native growth characteristic of the different soil areas, the length of time the latter have been under cultivation, the systems of rotation and fertilization practiced, the physical nature of the soils in the field, and the taking of samples from the different phases of soils within a geological area. This is carried on in connection with a geologist, as he works out in detail the boundaries of the various formations, thus utilizing in co-operation the knowledge of one specialized in geology with that of one specialized in soils and agriculture. The soil chemist determines the plant-food contents of the soils, their acidity, etc., which enables him in a way to suggest what elements of plant-food should be added, and also whether or not liming is necessary. A rather elaborate system of pot culture experiments has been in progress with soils which have been collected from various geo-

logical formations. The soils are taken from areas typical of the predominating types, and equal amounts are weighed out in a series of pots to which the limiting elements of plant-food (nitrogen, phosphorus, and potassium), are added in the various combinations possible. Photographs are made of the pots from time to time, and records kept of the comparative growth and yields of the different pots. Though this method of investigation is carried on under rather artificial conditions, it is felt that some very important results have been gotten, which are really an index as to what should be done in the field under natural conditions on the various soil areas. Yet we shall never feel absolutely satisfied with these results until they have been duplicated with experiment fields under natural conditions, and with different systems of rotation on the different soil areas in the State."

The making of a soil map is not a simple proposition, if the map is to be of real service, especially where there is such a diversity of soil conditions as obtain in Kentucky. In order, therefore, that a basis for an intelligent, systematic, and economical programme for the study of the soils of our more difficult formations might be obtained, areas in the Waverly, the Chester and St. Louis, and the Coal Measures were selected for study in 1908 and 1909. As representing Waverly areas where fertilizing seemed to be especially indicated, Green, Adair and Taylor counties were selected, and Mr. Jones spent the season of 1908 in those counties, the geology being determined by Prof. A. M. Miller; for the areas especially marked by Chester rocks, with St. Louis also present, Meade and Breckenridge counties were chosen; and, as a matter of economy, for certain phases of the Coal Measures, areas in the Central City and Madisonville quadrangles, in the near-by Western Coalfield, were selected for the field work of 1909. In the geologic work, Mr. Jones had the assistance of Dr. Foerste in Meade and Breckenridge counties, and that of Mr. Hutchinson in the Central City and Madisonville quadrangles. An abstract of the very useful report of Mr. Jones, covering results in the areas named, is given in this report.

According to a note furnished by Dr. A. M. Peter, more than 600 partial analyses of soil samples collected by the Sur-

vey from Western Kentucky have been made in the laboratory of the Experiment Station, and (as indicated by the report of Mr. Jones) pot experiments have been made on several types of soils. Dr. Peter considers that the most important result so far obtained in the chemical and pot experiments is that phosphate is generally needed on Western Kentucky soils, which is confirmation of the older work of the Survey and Experiment Station.

Chemistry and Technology.

During the period covered by this report, nearly 360 analyses have been made of samples collected by the Survey and sent for analysis by citizens of the State. In addition, very many specimens of rocks and minerals have been examined qualitatively for citizens of the State. As a rule, analyses of Kentucky rocks and minerals are made without charge, and it is to be regretted that a few of our citizens, taking advantage of this, have plied the Survey with samples for free analysis and then exhibited a critical spirit whenever there should be any delay in reporting results. It should be remembered that, with sincere disposition to serve every one, it is impossible for the Survey chemist to make analysis of all samples received at once; the rule of the mill must be followed. Moreover, it should be understood that unless labels accompany samples sent in we can not identify them, and they must be sent to the waste heap.

In obedience to the requirements of the law, determinations of the heating values of coals are carried on. A Parr and an Emerson calorimeter have been added to the equipment of the laboratory, and determination of b. t. u's. are made by both. This work is in the hands of Mr. R. D. Quickel, whose results for many samples are given in this report.

The testing of clays is in the hands of Prof. H. D. Easton. Some eighty burning and other tests have been made of clays from Ballard, Carlisle, Clark, Crittenden, Edmonson, Fayette, Hardin, Hart, Hopkins, Jefferson, Larue, Madison, Powell, Taylor, and Wolfe counties, representative of various types of clays and shales. Results show clays fit for many purposes,

including white ware, drain tile, No. 1 face brick, roofing and similar tile, terra cotta, fire-proofing, firebrick, etc., in addition to ordinary brick.

Professor Easton and Mr. Quickel are members of the faculty of the College of Mining Engineering of the State University, hence the work placed in their hands is carried on at much less cost to the Survey than otherwise would be the case.

One of the immediately commercially important technologic investigations conducted by the Survey, within the period covered by this report, has consisted of tests for the separation of galena from barytes in a simple way, without preliminary close sizing and yet with limitations as to minimum size of the barite fragments, with the largest possible return of clean barytes in suitable form for bleaching. The work, which was undertaken at the request of one of the Central Kentucky barytes plants, was done in the mining laboratory of the College of Mining Engineering, without cost to the Survey, by W. W. Shelby, jr., a Fellow in the College. Entirely satisfactory results were obtained, thus making available for use in grinding mills at nominal extra cost "leaded" barytes which hitherto could be used not at all or only for a very inferior "off-color" product.

Though keenly aware of the immediate and exceeding importance of the provision of the Survey law relating to an investigation of mine gases and coal dusts, I have been unable, so far, to take up that work. For it to be carried on, certain additions to the apparatus of the laboratory are necessary, and since the expenditures of the Survey have necessarily been kept within limits less than the annual appropriation, the means for the purchase of the apparatus have been lacking. It is hoped that with the coming year (1910-'11) it may be possible to undertake the investigation.

Present Limitations on Survey Operations.

Appropriations for the Survey are entered to its credit so as to conform to the State's fiscal year, July 1, to June 30. In consequence of the condition of the treasury, and in deference to the views of the Governor, $10,000 of the appropria-

tion for the year July 1, 1908, to June 30, 1909, was not used, and $5,000 of that for the year ending June 30, 1910, will not be used. This explanation is given in order that it may be understood, in the regions concerned, why plans which had been formulated for extensive topographic mapping in 1908 and 1909 have been so greatly curtailed, and why some other projected operations have been deferred. All officials concerned have given the Survey hearty support, but it has been felt desirable to keep its expenditures as low as possible without serious detriment to the service until the critical condition of the treasury could be bettered. It is expected that with the opening of the coming fiscal year the full annual appropriation may be used.

Co-operative Mapping.

In the topographic mapping carried on in co-operation with the U. S. Geological Survey, the latter meets the State Survey's allotment for such mapping with an equal amount. Under more favorable financial conditions, therefore, we would now be getting $20,000 worth of mapping annually for an annual expenditure of $10,000 (the amount authorized in the Survey act.) This would enable us to make rapid progress with the preparation of accurate maps so badly needed, especially in the Eastern Coalfield and in the southern tier of counties extending westward from the Cincinnati Southern railroad. For the reasons just given, however, the full amount of the State Survey's authorized allotment has not been used for 1908, nor will it be used during the current fiscal year. For the year 1908-'09 the sum of $3,000 was allotted (making $6,000 of Federal and State funds combined), and for the year 1909-'10, the sum of $5,000 was allotted (making a combined State and Federal allotment of $10,000.)

The programme agreed upon and carried out for 1908-'09, included the completion of the Princeton quadrangle, primary control of the Morgantown, Rochester, and Horsebranch quadrangles, and the beginning of primary triangulation for mapping Lewis and Rowan counties—the latter having less in the way of maps than any other counties in the State. In ad-

dition, triangulation for control of the Kentucky portion of the Williamson quadrangle was completed, and that for the Eastern half of the 30-minutes Prestonburg quadrangle was commenced. This carried the topographic work of 1908 over the larger part of Caldwell, a small fraction of Hopkins, and parts of Lyon, Muhlenberg, Ohio, Logan, Grayson, and Butler counties in the West; and portions of Lewis, Rowan, Carter, Greenup, Fleming, Morgan, Menefee, Bath, Martin, Johnson, Floyd, and Pike counties in the East.

The programme for 1909-'10 includes the completion of the Dawson Springs quadrangle, the completion of the 15-minute Monticello quadrangle, continuation of the primary triangulation for Lewis and Rowan counties, primary control of the Kentucky portion of the Warfield quadrangle, and primary triangulation, primary levels, and partial road traverse of one-half of the Prestonburg 30-minutes quadrangle. This carries the work over parts of Hopkins, Christian, Caldwell, and Crittenden counties in the West; over a considerable part of Wayne and over a small fraction of Russell, in the south-central region; and over parts of Rowan, Carter, Lewis, Fleming, Mason, Martin, Johnson, and Floyd counties in the East.

It is manifest that, with the comparatively small sums available for the respective years, satisfactory progress has been made. A condensed statement of the areas covered, miles of traverse run, stations set, etc., up to December 31, 1909, furnished by the Acting Director of the U. S. Geological Survey, is given elsewhere in this report.

Miscellaneous.

As part of the miscellaneous work of the Survey during the years 1908 and 1909, a number of special investigations were made at the request of various citizens. They included, among others, examinations of asphaltic sandstone in Logan county, limestones in Powell and Wolfe for use in connection with the Red river clays in the manufacture of portland cement, supposed occurrences of lead in Knox, of gold in Marion, and of silver in Menefee, also of barytes in the latter county; investigations of declining springs in Clark and Nicholas, with a view

to finding a basis for advice as to methods that might restore their vigor; of calcite deposits in Mercer, and of lead and zinc deposits in Bourbon, with a view to preparing plans for their mining and treatment; of deposits of lithographic limestone in Meade and Bath, etc. Also, a rapid reconnoissance was made of Lewis and Rowan counties, the results of which are briefly summarized by Mr. Fohs elsewhere in this report.

Work in Progress or Projected.

Following is a brief statement of some of the work in progress or projected:

1. Continuation of the work in the coalfields, including the deliniation of the outcrop lines of the more important coals of the Eastern field as soon as the topographic mapping has advanced sufficiently.
2. A report on the structural materials and other natural resources of Rockcastle county, as representative of areas carrying the best developments of Chester and Ste. Genevieve beds in that region.
3. A report on cannels.
4. Coking tests, including experiments in blending coals. Should the latter prove successful, it will mean the extension of the life of some of the highest grade deposits many years beyond what may otherwise be their history. The investigation will require the erection of a small, practical coking oven, with necessary accessories.
5. A systematic study of water horizons, and the investigation of stream pollution. It is hoped that co-operative arrangements may be effected with the water-supply division of the Federal Survey for carrying on this work.
6. Continuation of the soil survey.
7. Continuation of oil and natural gas investigations.
8. Study of the structural materials of the State, including building stones, stone fit for lime, cement materials, etc.
9. Resumption of the field study of the clays, and continuation of burning and other tests. This will require the services of a geologist fitted for such especial work, and tentative arrangements to that end have been made.

10. A series of drill holes to prove up certain areas in the Western and Eastern Coalfields, and to make tests in the "Purchase" for oil and gas.

11. Mechanical tests of limestones and sandstones for structural purposes. A tentative arrangement for this work, with the College of Mechanical Engineering of the State University, is under consideration.

12. Revision of the report on Warren county, by the author of the original, to bring it up to date with respect to geological subdivisions and to include more recent data concerning asphalt rock, cement materials, etc.

13. Continuation of study of the Sub-Carboniferous formations.

14. Surveys of such counties as the state of topographic mapping may warrant. It should be understood, however, that, properly, the detailed county surveys can not be undertaken as a major proposition until after the more general investigations shall have been approximately completed; but it should soon be possible to take up several counties each year. When the county surveys shall be taken up in a continuous way, the Director will ask for the appointment of an advisory board.

Disbursements.

Although the Survey is credited with its appropriations according to fiscal years, the Director's reports of expenditures are required to be checked up with the Auditor's books according to quarters of the calendar year; moreover, the field plans of the Survey are necessarily adjusted to calendar years and allotments are spread so as to accord with such plans. The following report of expenditures, showing "amounts expended, under proper heads, and for what purposes," is, therefore, made up according to calendar years.

ACCOUNTS PAID IN 1908.

Geology.	Pay	Expenses	Total.
Salaries	$3,630.42		
Field and allied expenses		$1,118.40	$4,748.82
Soil Investigations.			
Salaries (exclusive of geologists),	300.00		
Field expenses		24.50	324.50
Chemistry and Laboratory			
Salaries	1,126.66		
Apparatus and supplies		239.46	1,366.12
Technology of Clays.			
Salaries	500.00		
Apparatus and Supplies		55.75	555.75
Oil Well Survey.			
Salaries (delayed account)	24.10		
Notary fee		.50	24.60
Office.			
Salaries, (three)	1,360.00		
Supplies, postage, telegrams, telephones, typewriter repairs, P. O. box rent, account books,		96.09	1,456.09
Drafting.			
Salary (one, three months)	375.00		375.00
Museum.			
Labor in unpacking cases and placing specimens, arranging and indexing maps, miscellaneous supplies, (soap, etc.), miscellaneous labor,		102.77	102.77
Library.			
Technical books, book-case, cataloguing books, cross-indexing books, papers, maps, etc.,		118.69	118.69
Equipment and Repairs.			
Repair of transit		.50	.50
Freights and drayage		86.10	86.10
Director.			
Pay at $25 per month,	300.00		
Traveling expenses		44.06	344.06
	$7,616.18	$1,586.82	$9,503.00
Co-operative mapping.			
Salaries, subsistence, miscellaneous expenses,			4,075.04
			$13,578.04

ACCOUNTS PAID IN 1909.

	Pay	Expenses	Total.
Geology.			
Salaries,	$3,909.92		
Field and allied expenses,		$1,754.50	$5,664.42
Soil Investigations.			
Salaries (exclusive of geologists),	919.98		
Field expenses,		172.14	1,092.12
Chemistry and Laboratory			
Salaries, (two,)	1,825.00		
Apparatus and supplies,		525.69	2,350.69
Technology of Clays.			
Salaries,	600.00		
Fuel oil for kiln,		4.50	604.50
Fuel Testing.			
Salaries,	350.00		
Field expenses, (collecting samples,)		64.55	414.55
Office.			
Salaries, (three),	1,650.00		
Supplies, 2 desks, telegrams, telephones, P. O. box rent, printed statistical sheets, postage,		181.73	1,831.73
Drafting.			
Salaries,	1,000.00		
Proof-reading of maps, drawing special map,		10.00	1,010.00
Collecting Statistics, in co-operation with U. S. Geo. Survey.			
Pay, (one man,) 6 months,	150.00		150.00
Museum.			
Indexing maps, miscellaneous work	129.85		
Supplies,		5.05	134.90
Library.			
Cataloguing, Indexing documents, etc.	70.00		70.00
Testing Laboratory.			
Springs for Shaw gas machine,		6.74	6.74
Equipment and Repairs.			
Drafting supplies, repairing tape, repairing barometers, field kit box for maps, etc., drawing board, typewriter repairs, muslin for maps, Venus pencils,		66.31	66.31
Freights and drayage,		57.40	57.40
Director.			
Pay at $25 per month,	300.00		
Traveling expenses,		21.36	321.36
	$10,904.75	$2,869.97	$13,774.72
Co-operative mapping.			
Salaries, subsistence, miscellaneous field expenses,			5,618.53
			$19,393.25

ABSTRACT FROM PRELIMINARY REPORT OF THE SOIL SURVEY.

By S. C. Jones.

Since July, 1908, the soil survey has been carried on more in detail than during previous years. In the work now being done the soils and agricultural conditions are studied in connection with the geology. For instance, a man with a knowledge of soils and agriculture works in co-operation with a geologist, and thus is enabled to know the geological origin of the various soil types and thereby determine the relation soil areas bear to geological areas.

The work is carried on either by counties or by quadrangles. In areas where the co-operative mapping has been completed, the maps show the topography of the county and the boundaries of the bottom land, etc., in such detail that work can be very much facilitated; hence it is better to work in such areas than in those of which only "plane surface" maps are at hand.

During the summer of 1908, Adair, Green and Taylor counties were gone over. These counties lie in Southern Kentucky, mainly in the Mississippian areas. In the summer of 1909, field work was confined to Western Kentucky. The early part of the summer was spent in investigating the soils and geology of Breckenridge and Meade counties, while the latter part was spent in investigating the soils and geology of the Central City and Madisonville quadrangles. These quadrangles lie in the central part of the Western Coalfield and are no doubt quite typical of this area. In this area there are hundreds of square miles of bottom land that present many problems, such as drainage, acid soils, etc. During the preliminary investigation in former years, the soils along the river and creek bottoms were excluded, since they were thought to represent the richest soils in the State and were thought to be highly productive under almost any system of cultivation, but a more detailed study reveals the fact that these soils present perplexing problems as well as those of the upland, and for this reason practically as much attention is given to them as to the upland soils.

The field operations consist of such work as outlining and

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mapping the various soil areas in a county or quadrangle with a careful collection of a number of typical samples from both the surface and sub-soil of each area. At the time of taking samples, the physical nature of both the surface and sub-soil is carefully considered, as the soil exists under natural conditions in the field. Also, a careful study is made of the systems of farming and fertilization practiced, and the effects of each, judging from observation and from information obtained from farmers.

After the work of a county or quadrangle has been completed the facts observed in the field are outlined in detail in a more or less systematic order.

For instance, in a report on a county, its location is given, i. e., the portion of the State it occupies, with the number of square miles of territory within its borders, etc., with a brief description of the general geology, topography and drainage of the county. Then the soil-types occurring in the county are taken up and described in detail, giving the location in the county, the relation to other types, origin, etc., i. e., whether the soils of an area are derived from limestone, sandstone, shale, or whether derived from all these, as are many of the transported soils occurring along streams or where the geology is diversified, giving rise to soils derived from all these materials. The report also includes a detailed description of the topography of the type, with a description of the drainage, whether natural or artificial, etc. In a description of the surface soil the depth is given with the name. For instance, whether a clay, clay loam, loam, sandy loam, or sand, the name, of course, depending on the amount of clay, silt or sand predominating in a soil as is indicated by its physical nature. Color also plays a part in naming soils, as, for instance, yellow clay loam or gray sandy soil, etc. A brief description is made of the texture or granulation and physical composition, as, for instance, the kind of sand or silt composing a soil, whether fine or coarse, its compactness, perviousness to water, etc., with an estimation of the organic content as indicated from its general appearance.

In a like manner the sub-soil is described. It is sampled only to a depth of 18 inches, but is often examined to a depth

of 30 inches by means of an auger that is carried in the field at the time of sampling.

The report also includes a description of the native vegetation occurring on a soil area, with the kind of crops grown, their yields and the length of time cultivated. Also, the methods of plowing, depth, time, etc., are described with the sort of system of cultivation, whether shallow, deep or level. Such facts are considered because they are factors in conserving soil moisture, in making available plant food, and in preventing erosion or washing of soils.

Laboratory Investigations.

In connection with field investigations, laboratory work is carried on, in which chemical and physical analysis of the soils from the various soil areas are made. Along with the chemical and physical study of the soils a very elaborte system of pot culture experiments is being carried on in the soil fertility green-house at the Agricultural Experiment Station.

The laboratory investigations and pot culture experiments are carried on in co-operation with the Agricultural Experiment Station.

That portion of the investigation which has to do with field work, with soil physics and fertility (pot culture experiments) is carried on with funds furnished by the Survey, while the Experiment Station furnishes the soil fertility green-house, the laboratories and the soil chemist.

The soil samples collected by the parties in the field are sent to the Experiment Station, where the soil chemist determines their plant food content and their acidity, etc., which enables him in a way to suggest what elements of plant food should be added, and also whether or not liming is necessary.

The physical analysis of a soil consists in determining the proportions of clay, silt, and sand entering into its composition. In order to understand the problems relating to soil texture its physical characteristics must be studied. These characteristics are dependent on the dissociated particles, and the analyses are therefore of prime importance in determining and giving an understanding of different soils. In studying

soil factors in crop production, much depends on porosity and capillarity. The capacity of a soil to hold water depends upon the diameter and size of their interval surface.

To add further value to the analysis, pot culture experiments are now in progress in the new fertility green-house with soils which have been collected by the Geological Survey from various geological formations in the State. This work was also carried on last winter and many interesting results were obtained. The soils were taken from areas typical of the predominating types, and equal amounts are weighed out in a series of pots, to which the limiting elements of plant food (nitrogen, phosphorus and potassium), are added in the various combinations possible.

Manure, ground rock phosphate and ground limestone are also used.

Soils from Breckenridge and Meade Counties.

In the territory included in these two counties there is, in a general way, two great soil areas. One derived largely from a formation known as the Chester sandstone, and the other from a formation known as the St. Louis limestone. These divisions are known locally as "Sandstone and Limestone areas." Though in detail each contains within itself quite diversified geology, in a general way they may be divided into only two areas.

Corn, wheat, tobacco and hay are the principal crops grown in these counties. The average yield of corn per acre in Meade county in 1908 was 20.4 bushels; of wheat 9.3 bushels, tobacco 722 pounds, and hay, .67 tons. The average yield of corn per acre in Breckenridge county for the same year was 17.2 bushels; wheat 9.1; tobacco 721 pounds, and hay .56 tons.

These yields point to the fact that either these soils are deficient in plant food or that very poor systems of farming are employed. The real gist of the matter is that both of these

facts are true. The fact that the former is true is confirmed by a chemical analysis of the soils, which shows that they are extremely deficient in the elements, nitrogen and phosphorus. The fact that the latter is true, one may decide for himself if he will only observe and study the systems of farming now employed in these two counties.

Chemical Analysis of the Soils.

So far the chemical analysis of the soils of these counties is incomplete. The total phosphoric acid, total nitrogen and amount of lime required to neutralize the acid in these soils have been determined. The total potassium, which of course will furnish valuable information, has not yet been determined. Again, when work on the available plant food has been done, further valuable information will be furnished.

Including both surface and sub-soil, the phosphoric acid, nitrogen and lime requirements have been determined in 124 samples that were taken during the summer of 1907.

Of the 124 samples analyzed, 32 were from the surface and 16 from the sub-soil of the limestone area, while 60 were from the surface and 16 from the sub-soil of the sandstone of Chester area.

Below are given the analyses of those from the "limestone area."

SURFACE.				SUB-SOIL.			
Sample No.	Acidity (Hopkins.) CaO%	P_2O_5%	N%	Sample No.	Acidity (Hopkins.) CaO%	P_2O_5%	N%
1	.005	.101	.091	2	.084	.097	.050
3	.002	.100	.155	4	.034	.085	.055
5	.002	.093	.085	8	alk. .0022	.121	.074
6	.004	.077	.057	10	.501	.068	.041
7	.001	.154	.122	15	.001	.094	.077
9	.002	.094	.090	18	.091	.070	.038
11	.002	.085	.075	22	.013	.073	.055
12	.067	.093	.085	27	.037	.061	.041
13	.013	.068	.070	29	.532	.048	.041

Sample No.		CaO%	P_2O_5%	N%	Sample No.	CaO%	P_2O_5%	N%
14		.002	.115	.127	32	.161	.053	.040
16		.002	.116	.106	43	.041	.055	.049
17		.002	.078	.096	45	.501	.040	.032
19	alk.	.123	.070	.062	48	.073	.042	.036
20		.001	.101	.106	50	.021	.073	.046
21		.003	.101	.106	53	.223	.051	.019
23		.000	.257	.208	61	.002	.086	.079
24		.002	.051	.085				
25		.030	.073	.065				
26		.001	.083	.073				
28		.002	.061	.082				
30		.042	.060	.078				
31		.051	.055	.060				
42		.002	.070	.086				
44		.003	.055	.078				
46		.008	.087	.102				
47		.002	.057	.093				
49		.002	.086	.094				
51	alk.	.0038	.065	.078				
52		.032	.070	.042				
60		.002	.086	.079				
62		.014	.083	.092				
79		.002	.080	.095				

Below are given the analyses of the samples taken from the Sandstone area.

SURFACE. **SUB-SOIL.**

Sample No.		Acidity (Hopkins.) CaO%	P_2O_5%	N%	Sample No.	Acidity (Hopkins.) CaO%	P_2O_5%	N%
33		.001	.055	.070	34	.013	.071	.044
35		.001	.086	.134	37	.024	.063	.044
36	alk.	.0067	.084	.086	55	.168	.053	.035
39		.002	.064	.073	65	.083	.061	.032
54		.011	.055	.083	72	.130	.068	.039
56		.003	.068	.097	74	.076	.080	.064
57		.002	.066	.062	84	.002	.080	.074
58		.003	.078	.094	88	.002	.064	.045
59		.010	.088	.080	90	.002	.069	.053
63		.003	.083	.076	94	.003	.066	.046

SURFACE.

Sample No.	CaO%	P_2O_5%	N%
64	.006	.083	.100
66	.003	.074	.119
67	.006	.049	.093
68	.001	.048	.099
69	.017	.066	.095
70	.092	.061	.086
71	.001	.085	.075
73	.003	.090	.121
75	.016	.073	.079
76	.047	.063	.073
77	.004	.065	.117
78	.002	.088	.134
80	.002	.080	.095
81	.003	.078	.104
82	.001	.081	.081
83	.002	.096	.097
85	.002	.025	.107
86	.001	.103	.125
87	.001	.031	.093
89	.001	.080	.098
91	.003	.098	.073
92	.045	.080	.111
93	.001	.080	.102
95	.003	.083	.101
97	.004	.070	.070
98	.001	.073	.077
99	.008	.079	.123
100	.003	.089	.117
102	.002	.060	.112
103	.008	.073	.095
104	.011	.059	.070
105	.003	.074	.087
106	.003	.089	.112
107	.001	.080	.114
108	.101	.065	.099
110	.002	.049	.111
111	.003	.070	.082
112	.001	.096	.092
113	.031	.059	.068
114	.002	.045	.105
115	.002	.072	.079
117	.003	.102	.111
118	.003	.100	.114
119	.015	.074	.091

SURFACE

Sample No.	CaO%	P_2O_5%	N%
120	.003	.071	.084
123	.003	.065	.098
124	.003	.063	.103
125	.000	.103	.098
127	.001	.084	.140

SUB-SOIL.

Sample No.	CaO%	P_2O_5%	N%
96	.035	.065	.057
101	.006	.060	.057
109	.034	.054	.053
116	.063	.067	.049
122	.009	.066	.060
128	.002	.086	.093

It will be seen that the different samples of soil from both areas vary considerably in the percentages of phosphoric acid and nitrogen they contain, and also in the amount of lime required to neutralize the acid.

The total average of the many samples analyzed from the surface and sub-soil of these two areas bring out many interesting points as are indicated in the tabulation below.*

SURFACE SOIL.

Lime to neutralize acid.

	CaO %	P_2O_5 %	N %
Average for Limestone Soil	.0104	.0882	.086
Average for Sandstone Soil	.006	.0742	.096

SUB-SOIL.

Lime to neutralize acid.

	CaO %	P_2O_5 %	N %
Average for Limestone Soil	.154	.068	.047
Average for Sandstone Soil	.044	.067	.058

The surface and sub-soils of the limestone area are much more acid than those of the sandstone area, and in both areas the sub-soil is much more acid than the surface. Over an acre to a depth of seven inches there is approximately two million pounds of soil. Figuring on this basis it would require 208 pounds of lime to neutralize the acid in the surface of the limestone soil, while for the same amount of the sub-soil it would require 3080 pounds. To neutralize the acid in the surface of the sandstone soil would require only 12 pounds, but for the same amount of the sub-soil 880 pounds would be required.

	SURFACE.		SUB-SOIL.	
	Phos.	Nitrogen.	Phos.	Nitrogen.
Limestone soil	....738 lbs.	1620 lbs.	....567 lbs.	940 lbs.
Sandstone soil	....638 "	1920 "	....566 "	1180 "

*CaO stands for lime; P_2O_5, for phosphoric acid; N, for Nitrogen.

The surface soil of the limestone area is much richer in phosphorus than that of the sandstone area, containing 100 pounds more per acre, while the sub-soils of the two areas are practically the same. It would, of course, be expected that the limestone soil would be richer in phosphorus, since the limestone from which it is formed is largely of animal origin.

Both the surface and sub-soil of the sandstone area are much richer in nitrogen than the surface and sub-soil of the limestone area. This is probably due to the fact that the limestone area has a topography more favorable for erosion and much of the nitrogen is carried away mechanically with the soil.

Pot culture experiments are now being carried on with the soils taken from these two areas that will, no doubt, furnish much more valuable information.

Results obtained from Green, Taylor and Adair County Soils

There are a number of soil areas in these counties, derived mainly from the St. Louis, Waverly and Coal Measures formations. These areas have been mapped and the soils and agricultural conditions described. Also a number of chemical analyses have been made of both the surface and sub-soil taken from the various soil areas, and very interesting results have been obtained from pot culture experiments.

In the tabulation below are given the results of the chemical analyses of both the surface and sub-soil of five samples taken from soils derived from St. Louis formation, eight from soils derived from the Waverly, and three from soils derived from the Coal Measures. The fifth normal nitric acid solution is supposed to extract from soils the amount of potash and phosphoric acid readily available to plants, hence we have available potash (K_2O) and available phosphoric acid (P_2O_5) as shown in the following tables.

SURFACE OF ST. LOUIS.

Lab. No.	Sample No.	Acidity (Hopkins) CaO	Total K_2O	Total P_2O_5	Total N	Avail. K_2O *HNO_3	Avail. P_2O_5 *HNO_3	CaO *HNO_3
254	55	.0045	1.00	.0500	.088	.0295	trace	.125
254	61	.0045	.88	.0350	.078	.0260	.0046	.122
254	63	.035	1.10	.0625	.086	.0210	.0008	.114
254	69	.045	1.10	.0675	.104	.0475	.0030	.051
254	70	.034	1.14	.0638	.084	.0290	.0024	.089
			SURFACE OF WAVERLY.					
254	51	.0056	1.26	.0588	.102	.0155	trace	.076
254	53	.0039	1.16	.0663	.090	.0185	trace	.144
254	57	.1008	1.38	.0362	.074	.0150	trace	.054
254	59	.0036	.90	.0475	.092	.0330	.001	.108
254	71	.0022	1.85	.0638	.082	.0165	.0016	.176
254	73	.0062	1.47	.0613	.096	.0250	.0012	.080
254	79	.0045	1.12	.0875	.112	.0300	.0016	.111
254	81	.0034	1.13	.0638	.090	.0205	.0012	.108
			SURFACE OF COAL MEASURES.					
254	65	.0097	.95	.0350	.054	.0245	.0018	.054
254	69	.0056	.98	.0425	.064	.0300	.0018	.060
254	75	.0426	.67	.0488	.058	.0186	.0024	.027

*Fifth normal nitric acid solution.

SUB-SOIL OF ST. LOUIS.

Sample No.	Acidity (Hopkins)	Total K_2O	Total P_2O_5	Total N	K_2O *HNO_3	P_2O_5 *HNO_3	CaO *HNO_3
56	.0045	1.09	.0350	.045	.0435	trace	.111
62	.0616	.96	.0312	.040	.0355	.0008	.060
64	.0045	.88	.0425	.062	.0215	.0004	.136
70	.0090	1.16	.0463	.054	.0325	.0024	.098
78	.0294	1.29	.0613	.054	.0345	.0008	.089
			SUB-SOIL OF WAVERLY.				
52	.0762	1.38	.0450	.050	.0155	trace	.049
54	.0515	1.14	.0538	.048	.0290	.0004	.136
58	.1277	1.48	.0312	.044	.0160	trace	.073
60	.0056	.87	.0400	.048	.0270	.002	.084
72	.0024	1.87	.0625	.070	.0155	.0026	.157
74	.0828	1.10	.0538	.048	.0340	.0010	.046
80	.0056	1.05	.0650	.058	.0195	.0008	.117
82	.0504	1.24	.0500	.048	.0260	.0008	.080
			SUB-SOIL OF COAL MEASURES.				
66	.1014	1.26	.0400	.040	.0205	.0006	.051
68	.0655	1.13	.0375	.041	.0220	.0024	.054
76	.1232	.79	.0450	.040	.0280	.0012	.065

*Fifth normal nitric acid solution.

Below are given the averages of the St. Louis, Waverly, and Coal Measures soils expressed in per cent. and in pounds figured to the acre basis, i. e., the number of pounds of lime (CaO) required to neutralize the acid, the total number of pounds of the elements potassium, phosphorus and nitrogen, and the number of pounds of potassium and phosphorus dissolved by a fifth normal nitric acid solution.

AVERAGES FOR SURFACE SOILS.

	Acidity CaO	Total K_2O	Total P_2O_5	Total N	Avail. K_2O by $*HNO_3$	Avail. P_2O_5 by $*HNO_3$	CaO $*HNN_3$
St. Louis	.0044	1.04	.0557	.088	.0306	.0021	.1002
Waverly	.0162	1.28..	.0606	.092	.0217	.0008	.1079
Coal Measures	.0198	1.86	.0421	.059	.0245	.0020	.047

AVERAGE OF SUB-SOILS.

St. Louis	.0218	1.07	.0432	.051	.0338	.0008	.097
Waverly	.0502	1.26	.0528	.051	.0215	.0008	.093
Coal Measures	.0967	1.06	.0408	.040	.0235	.0012	.056

*Fifth normal nitric acid solution.

NUMBER OF POUNDS PER ACRE.

SURFACE SOIL.

	Lime to Neutralize Acid	Total K	Total P	Total N	Avail. K	Avail. P
St. Louis	88	17,264	479	1760	508	18.00
Waverly	324	21,248	521	1840	360	6.88
Coal Measures	386	14,276	362	1180	405	17.20
SUB-SOIL.						
St. Louis	436	17,762	372	1020	561	6.88
Waverly	1004	20,916	454	1020	357	6.88
Coal Measures	1934	17,596	350	800	390	10.30

The chemical analyses show that these soils, even from the same geological areas, vary quite widely in their plant food content.

The average analysis of the soils from each area shows many interesting facts. The surface soils of the Waverly

area are richest in total potassium, total phosphorus and total nitrogen, but poorest in available potassium and phosphorus as shown by the fifth normal nitric acid solution. The St. Louis soil is least acid. This is true of both the surface and sub-soil. In each area the sub-soil is more acid than the surface.

The soils of these areas are much poorer in phosphorus than those of the Chester and St. Louis areas of Breckenridge and Meade counties.

These samples show many other facts that will be brought out in the report on the soils of these counties.

Pot Culture Experiments.

For pot culture experiments, four lots of soils were taken from different soil areas. Two were taken from the Waverly formation, one from the St. Louis and one from the Coal Measures.

From each type of soil a series of pot culture experiments was carried on. Each series consisted of 17.4-gallon pots and in each pot 14,500 grains of soil were placed.

To give an idea of results obtained from culture experiments it will be necessary to include in this report the results of only one series. The soil used in this series was formed from limestone occurring near the top of the Waverly formation and is very different from the soil formed from the formation occurring near the base of the formation.

In this series the pots are numbered from 160 to 176 and plant food is added as indicated below.

No. 160 None.
" 161 None.
" 162 15 gr. $CaCO_3$ in the form of ground limestone.
" 163 6.4 gr. dried blood containing 12% nitrogen.
" 164 6.4 " " " plus 15 gr. ground limestone.
" 165 3.8 " dissolved bone containing 15% of phosphorus.
" 166 3.8 " " " plus 15 gr. ground limestone.
" 167 3.2 " potassium sulphate.
" 168 3.2 " " " plus 15 gr. ground limestone.
" 169 6.4 " dried blood plus 3.8 gr. dissolved bone.
" 170 3.8 " dissolved bone plus 3.2 gr. potassium sulphate.

" 171 6.4 " dried blood plus 3.2 gr. potassium sulphate.
" 172 6.4 " " " " 3.2 " " " plus 3.8 gr. dissolved bone.
" 173 20 gr. of rock phosphate.
" 174 35 " of dried manure.
" 175 35 " of " " plus 20 gr. rock phosphate.
" 176 35 " of " " " 20 " " " plus 15 gr. ground limestone.

The soil used in this series is a heavy loam underlain by a heavy red sub-soil. A chemical analysis shows it to be much richer in plant food than the analysis of the eight samples given above from the Waverly.

The surface soil contains 2,280 pounds of nitrogen to the acre, 1,040 pounds of phosphorus, and 21,590 pounds of potassium.

The fifth normal nitric acid solution shows an availability of 1.2 per cent. of the total phosphorus or 11.48 pounds per acre, 1.9 per cent. of total potassium or 410 pounds to the acre.

In the tabulation given below "none" means no treatment; I, means limestone; N, nitrogen; P, phosphorus; K, potassium; R, rock phosphate; and M, manure. Oats were grown in the pots and the yields are given below.

COMPARATIVE EFFECT OF FERTILIZERS.

Soil pot No.	Treatment Applied.	Straw+Oats. Gr. per pot.	Increase. Gr. per pot.	Oats. Gr. per pot.	Increase. Gr. per pot.
160	none	68	.....	10.8	.....
160	none	60.5	.....	11.1	.....
162	L.	65	.75	11.7	.75
163	N.	72	7.75	16.5	5.55
164	N. L.	58.5	— 5.75	13.5	2.55
165	P.	85	20.75	12.6	1.65
166	P. L.	95	30.75	14.5	3.55
167	K.	46	—18.25	9.3	— 1.65
168	K. L.	55	— 9.25	8.5	— 2.45
169	N. P.	128	63.75	28	17.15
170	P. K.	95	28.75	14.2	3.35
171	N. K.	75	11.25	13.5	2.55
172	N. P. K.	131	66.75	24.5	13.55
173	R.	69	4.75	13.5	2.55
174	M.	71.5	7.25	10	— .95
175	R. M.	75	10.75	15.7	4.15
176	R. M. L.	92.5	28.25	13	2.05

The increase in the yield of the pots containing the fertilizers is computed from the average yield of the duplicate unfertilized pots.

Ground limestone, nitrogen, phosphorus and rock phosphate show an increase in yield in both whole crop and grain, while potassium alone and in combination with ground limestone, shows a decrease in both. Manure alone increased the whole crop but gave a slight decrease in grain. Ground limestone and nitrogen show a decrease in total crop but an increase in grain. All other combinations show an increase in both whole crop and grain. Phosphorus alone and in combination shows in every instance a decided increase in the quantity of the whole crop, but a very slight increase in grain, except in combination with nitrogen, which causes a very marked increase. Nitrogen and phosphorus give a greater increase in grain than nitrogen, phosphorus, and potassium combined.

These results indicate that nitrogen and phosphorus should be added to this soil. The nitrogen should be obtained from the atmosphere by growing legumes, such as peas, beans, clover, or alfalfa. These crops can be fed and the manure returned or turned under directly. Phosphorus should be supplied in some condensed form as bone meal or as finely ground rock phosphate. The latter would be much cheaper and when turned under with manure or green crops would probably in the long run give as good results.

REPORT ON THE COAL BEDS OF THE TUG FORK REGION: MARTIN AND PIKE COUNTIES, KENTUCKY.

By A. R. Crandall.

Reports on the Geology of the Big Sandy river valley giving the order and dip of beds, in a general way, have been published from time to time by the State Geological Survey. Bulletin No. 4, presented the first connected view of the field as a whole, with reference to equivalency and character of rocks and of economic beds. Of necessity some localities were only partly explored, or inadequately developed by systematic work, for which time and means could not be encompassed.

Recently additional work has supplied the data for a supplemental report on the Tug Fork region, which will add much to the value of the showing in that region and will clear up some questions of equivalency of beds in this field. But consistent with what has been found in the field at large, the changes in numbers, thickness and character of economic beds of the including rocks is so great, even in this smaller field, as to make the recognition of a definite serial order of beds in some parts of the vertical section no more than a provisional standard for purposes of description.

These variations in character and thickness are well illustrated in a series of hill sections along the Tug river from Warfield in Martin county to the West Virginia line above the mouth of Knox creek in Pike county. For purposes of comparison, these sections may be placed in their distance relations in a series of diagrammatic representations of the vertical order of beds, in which some of the coal seams are readily traced in a general way at least, as representing identical geological levels. This aid in the description of the geological bed plain of the Tug Fork is given in the accompanying

Plate of vertical sections along the Tug river from Warfield to Alnwick in West Virginia.

The Warfield coal, the No. 1, of former reports, is at the base of the series of beds above the drainage level at Warfield. Drill wells in the region also show that here it is the first workable coal seam above the Conglomerate formation, the lower coarse, more or less conglomeratic, formation of the Coal Measures. This is also true of the Paintsville coal, the Prestonsburg seam, the lower Little Fork coal near Willard in Carter county, and other coal exposures that have been regarded as at the Warfield coal horizon.

The thickness of rock beds at Warfield, down to the Conglomerate formation, appears from the well record to be 441 feet. The record of a five-foot coal, 140 feet below the Warfield seam in this well is probably an error incident to oil well drilling. In other wells in the region, one or two thin coals near the 200 and 400-foot levels below the Warfield seam occur. On Cold Water Fork of Rockcastle creek a few miles West of Warfield, no coal was found. On Little Crooked branch of Wolf creek, six miles Southwest of Warfield two 2-foot coals are noted at the 210 and the 327-foot levels. These beds are important chiefly for comparison with the lower Knox creek coals of Tug Fork, the Ellswick and Auxier seams of Russell Fork and the corresponding beds on the Levisa Fork above mouth of the Russell Fork and the lower coals of the Knox creek valley, as also with the War Eagle coals in West Virginia. The interval between Coal No. 1 and the conglomerate rock is about 200 feet at Paintsville in Johnson county. In the wells previously mentioned about Warfield, this interval is increased to a maximum of 510 feet. Up the Tug river these intervening beds increase in thickness to about 900 feet at Alnwick, West Virginia, and the coal beds included also become more prominent and are increased in number, two or three becoming minable beds in the Knox creek region. The Williamson well record shows a coal bed 200 feet below the Warfield seam and a thin coal 204 feet lower. In a well on Meathouse fork of Big creek, 6 miles Southwest of Williamson, only one coal was noted above the Conglomerate beds and that at about 400 feet below the Warfield seam. These beds

are probably represented by the coal beds above the drainage at the head of the Left fork of Pawpaw creek of the Knox creek valley, about 200 feet below the Warfield seam, and the Rolly Dotson coal, 225 feet lower. These beds are 40 and 30 inches thick. Near the forks of Pawpaw, two beds are found only about 60 feet apart; the upper 42 inches (reported) probably the same as the latter, and the lower, near the creek bed showing 34 inches of coal in one bench, is about 480 feet below the Warfield seam as opened on the Right Fork.

Near the bed of Camp creek the valley next below Pawpaw creek, and about a mile from the mouth of the creek, a 41-inch bed of coal is opened under a prominent ledge of slaty sandstone, probably the upper of the last mentioned beds.

From Burnwell southward, the lower coals rise above the drainage in varying order as will be seen in the sections of the accompanying plate which, however, probably do not show all the coal seams that might be found. Two appear to mark horizons noted in oil wells in the Warfield Williamson region, mention of which has been made. They are also representatives of the War Eagle coals of Professor White's report on the coals of the upper Tug Fork valley in West Virginia.

The coal beds from the Warfield seam upward, present a variable series of minable coals, the equivalency and nomenclature of which is a matter of considerable interest aside from the special values which they give to this field from the thickness of beds and the average character of the coals.

The relation of these beds severally to beds of the same subdivision of the Coal Measures as found in the Kanawha Valley in West Virginia and in other like fields, has been the subject of considerable interest, from a laudable desire for a nomenclature of beds more suggestive than acquired local names. Observations by Dr. I. C. White, Director of the West Virginia Geological Survey, Vols. 2 and 2A, 1908, Coal Reports of that Survey, have added much comparative data in this direction, as also Professor John J. Stevenson, in an interesting paper on the "Carboniferous of the Appalachian Basin," Bulletin of the Geological Society of America, Vol. 15, pp. 37-210, and Dr. Orton, Vol. V., Ohio Geological Reports.

How far this comparative study can be made to give mining or geological significance to the name-designations of coal beds in current literature or in local use, depends very much on the view taken of the continuity of beds or how far the serial order of beds rather than definite continuity may be made the basis of nomenclature. It may be assumed that even in the great Appalachian coal field, including parts of Pennsylvania, Ohio, Maryland, West Virginia, Kentucky, Virginia, Tennessee and Alabama, a more or less comparable order of formations, and of series of beds characteristic of these formations may be recognized throughout.

But the continuity of individual beds of whatever kind over so wide and so varied a range of conditions of sedimentation as is indicated by geological features in the several States or in adjacent basins in the same State could hardly be supposed theoretically or maintained by observation. Coal seams are not exceptional as bed deposits; they increase in number and in prominence in more or less local basins and decrease in number or in thickness in adjacent basins of an equivalent series of rock beds, as found in developing the coal resources of a coal field. The recurrence of peat deposits in Carboniferous time was evidently not at successive geological levels coextensive with the Appalachian coal field, or even of the lesser fields into which it may be divided, but successive deposits in more or less local basins in such time and order as the inequalities of subsidence and of deposition may have determined; widening at some levels to overlap and increase the number of beds in the vertical section of one region, and retreating to leave a diminished number in that of another.

Rightly understood, therefore, the synchronism of beds of regions more or less widely separated by undeveloped regions, by using the same horizon-designations, should be regarded as having to do more with the comparative order of beds than with the exact equivalency or the continuity of the several beds of a series, and the value of such a nomenclature is the suggestiveness of subdivision relations as of the beds of the Kanawha series in the Kanawha Valley, and the same series in the Tug Fork valley rather than in the identity deemed more or less probable of the beds in the one field as compared

with those of the other. In the Coal Measures of Eastern Kentucky, several coal beds may be traced in a general way over the whole field, others are clearly more local in the Tug Fork region. Not all of the coal seams of the series are continuous over so limited a region, but for purposes of comparison with other fields the number and prominence of coal seams is not lacking.

In a general way, the Warfield seam, the first bed of special commercial value above the Conglomerate formation of the Lower Big Sandy Valley may be traced with such variation in character and surrounding over most if not all of the East Kentucky Coalfield. Towards the Pine Mountain it becomes the second and the third coal of importance in the series above the Conglomerate Measures. This, with the great thickening and change in the character of the rocks together with the increased dip, led formerly to the transfer of No. 1 to the next coal below (the Sicks coal, and the Auxier coal of Russell Fork), an error which is corrected by the Tug Fork sections, in which the Warfield coal is one of the pricipal horizon marks and will be described separately as the base of the series of beds which gives to the Tug Fork valley high rank as a coal region.

At Warfield, the thickness, as shown in an entry 25 to 30 feet above low water in the river or about 615 feet above tide water, was found to have a maximum thickness of five feet under a slaty shale roof.

Up the river past the mouth of Wolf creek this bed falls below the drainage or is not open to show its character and thickness.

At Borderland, nine miles above Warfield, the bed section of this seam shows prominent shale partings, which are not elsewhere characteristic of this bed; and this might be cited as evidence that it is not the Warfield seam if instances of variation equally great were not found in other beds in this region and other regions where the evidences of identity are more definite. The rock surrounding of this bed at Borderland is the usual predominating slaty shale of the lower Big Sandy valley.

The bed section at about 635 A. T. is as follows, thicknesses being stated in inches:

	Inches	Inches
Roof, slaty shale.		
Coal	13	....
Slate	....	5
Coal	18	....
Shale	....	16
Coal	9	....
Shale	....	6
Coal	23	....
	63	27

At Williamson this bed is below the high water level. It is reached at the 24-foot depth of the Williamson drill well (see the Williamson section) at about 638 feet above tide. The identity of the seam is indicated by the continued record of this well with a coal at 200 feet, and the top of the Conglomerate measures at 550 feet.

From Williamson to Burnwell, five miles up the river, the series of beds rise rapidly and this coal takes on the features which are characteristic and unmistakable, as traced into West Virginia in the Knox creek valley and across to the waters of the Levisa Fork in Kentucky and West Virginia. This bed, the Burnwell coal, as examined in several entries, shows some variation, as in the following description:

Roof, sandrock with shale intervening in places.

	Entry No. 1.		Entry No. 2.	
	Inches.	Inches.	Inches.	Inches.
Coal	5	....	4	....
Slaty or "laminated" coal	....	5	....	8
Soft coal	16	....	....	....
Parting, barely traceable				
Splint coal	16	....	....	....
Coal with cubic fracture	23	....	46	....
	60	5	50	8

The height of this bed above the sea is 774 above tide or 85 feet above Railway grade at Sprigg Station. The including rocks here show with increased sandstone ledges as compared with the Borderland section.

At the Freeburn mines, near the mouth of Peter creek, this seam is at 1090 A. T. (Bar.) railway grade being 727. The variations in thickness in the Peter creek valley are shown by many openings a few of which are given as an average representation.

	Freeburn Mine	Hatfield Br.	Rockhouse Fk.	Rep. by Clark Laynes	Beech Fk Coleman's C.
Roof.....Sl. to Ss.		Slate.	Slate.		Slate.
Coal	7	6	12	17	20
Slaty ("Bone")	6	5	8	7	3
Coal	46	44	54	49	40
	—	—	—	—	—
	59	55	73	73	63

Sandrock largely predominates in the section here, cropping out in regular ledges and cliffs.

Two miles above the mouth of Peter creek (Delorme station) this coal, the Vulcan seam of the Vulcan mines, is mined on the river front. It is also opened near the head of Barren She creek. The elevation above tide at the mine entry is 1195 feet. The face of the bed at the two openings measure as follows:

	Vulcan Mine.		Barren She Opening.	
Roof.....3	ft.	s. to ss.	Slaty shale.	
Coal	12	....	12	....
Slaty laminated coal	....	8	....	9
Coal	54	....	54	....
	—	—	—	—
	66	8	66	9

Here, as at Freeburn, the rocks above and below are cliff-forming sandstone in strong contrast, especially below, with the predominating shales in the Warfield, Wolf creek region.

Following this horizon up the river to Poplar creek the entries of the Majestic Mining Company's mines two miles up the creek, on Cow Branch and on Linn Trough branch, are at 1213 A. T., and show the following bed sections:

	Cow Branch.		Linn Trough Br.	
	Inches.	Inches.	Inches.	Inches.
Roof			8 sl. to sh. ss.	
Coal	19	....	18	....
Slaty	....	9	....	8
Coal, soft	....	....	12	....
Coal	55	....	48	....
	74	9	78	8

Ten feet above this bed on Cow branch a local 20-inch coal occurs in shales.

On Knox creek, which heads in West Virginia, a number of openings have been made, showing an increased elevation above sea level, with variations in bed section, but readily recognized as the Freeburn, Vulcan, Majestic, coal by the general features of the bed as well as by the thickness and surroundings. The following table gives some of these exposures; thickness in inches. Elevations from barometric observations and therefore only approximations.

	Elevation. A. T.	Roof.	Coal.	Slaty C.	Coal.	Total thick.
On Turkey Cr., Ferrills C.	1350	s.l ft.to ss.	12	7	50	69
On Turkey Cr., Blankenships C.	1340	Slate	15	8	58	81
On Turkey Cr., Robnets C.	1330	Slate	12	6	43	61
Hurricane Cr., Abe Blankenship's C.	1400	ss.	12	5	46	63
Pawpaw Cr., Rt. Fk., Hurley's C.	1450	ss.	43	8	30	81
Pawpaw Cr., Mill Br. C.	1400	ss.	33	6	18	57
Lusters Fk. of Knox Cr.	1650	sl.	30	2	31	63
Black Eye Fk. of Knox Cr.	1850	ss.	25	1 to 5	35	65
Ridge bet. Long Br. of Tug and Upper Elk Fk. of Knox Cr.	1750	sl.	13	6	39	58

In the three last openings which are in West Virginia, the elevations are especially subject to corrections for variations of barometer.

The mining operations southward from Wharncliffe and War Eagle in West Virginia, are from the rapid rise of beds up the Tug river restricted to the coal seams below the Warfield bed. They are known as the War Eagle coals previously referred to.

The foot of the greater dip as shown by the preceding description of the Warfield seam is at Williamson, where it is at about 645 ft. A. T. as compared with 620 feet at the latter place, 14 miles below, considerably less for this distance than the fall of the river. Southward from Williamson the rise is 740 feet in 16 miles or an average of 46 feet to the mile. The dip is, however, increased towards the West Virginia line in the Knox creek region as will be seen from the plate of sections, so that the dip in the district from Williamson to the West Virginia line increases from 38 to 55 feet per mile.

The vertical order of coal beds at Warfield compared with that to the Northwest, have been regarded as corresponding to coals 1, 2 or 2A, 3, 5, and 6. In the region at the head of Rockcastle, a skeleton section of which is shown on the section plate, the order is the same up to coal 5; the Broas seams, coals 6 and 7, are wanting there and No. 8 is the upper seam. At Whitehouse on the Levisa fork, coals 7 and 8 appear to be represented near the top of the ridge, No. 1 below the drainage and No. 2 or 2A the cannel coal of the Whitehouse mines. The Peter Cane section, a fork of the Pigeon Roost fork of Wolf creek. The order of the beds opened appear to be Nos. 1, 2, 5 and 7. With the order indicated in the localities to the North and West, the coal horizons of the Borderland mining district may at least tentatively be regarded as representing coals No. 1, 3, 5, 6, 7, 8, and 9, the Borderland seam being No. 8. The coal beds up the Tug fork are in a general way in the same order. By the thickness and character of the three or four lower beds of Borderland, with the rise of the rock layers up the river, these seams make up the great body of coal of the region.

The following lists of names apply to these beds in different localities:

No. 1 Coal.—The Warfield, of Martin county; the Paintsville and the Millers creek block of Johnson county; the Prestonsburg seam of Floyd county; the Burnwell, Freeburn, Vulcan and Majestic seams of the Tug Fork; and, on the Levisa and Russell Forks, the Lower Elkhorn seam. In West Virginia, the Warfield, No. 2 Gas, and Rowl.

No. 3 Coal.—The Peach Orchard seam, on the Levisa fork.

The Alma (?) seam of Tug fork. In West Virginia, the Alma Peerless and Mate creek.

No. 5 Coal.—The Watson coal of Levisa fork; Webb's and Young's coal of Cat fork, and Cherokee, in Lawrence county; the Broas Block coal of Martin county; the Thacker coal of Tug fork, and the upper Elkhorn seam of Levisa fork and of Russell fork in Pike county. In West Virginia it is the Thacker, Glenalum, and Red Jacket.

No. 8 Coal.—The "Eight-foot" coal, and F. coal of the Broas development, in Martin county; the Borderland seam of Tug Fork; and the Winifrede of West Virginia and of the Borderland district in Kentucky. Elsewhere on the Kentucky side of Tug river, this name has been applied to various beds without due regard to place in the series.

The other beds developed in this field are not so constant, or so widely developed as to be readily synchronized with coals in other regions in Kentucky.

The Williamson section of the high hill at the head of Buffalo creek, shows coals above the Winifrede, which are not included in the sections along the river in Kentucky. Back at the heads of Pond creek, Blackberry and Peter, the ridge points rise to 2200 feet or more above the sea, and include coals still higher than is included in the Buffalo creek section. Some of these are described in Bulletin 4, p. 67. Few of the ridges and spurs in which mining developments have been made rise above the 1600-ft. level. The thick coal described at the head of Pond creek (Bulletin 4, p. 67), 1200 feet above Pond creek, will be found in a few high points only; but this main ridge covers the largest area of the coals below the Borderland seam. The coal beds next above the Borderland seam, in the section at the head of Pond creek, show 36 inches or less as formerly opened by the Survey.

All the beds below and including the Borderland seam may be more or less specifically classed as caking coals; most of them vary from soft coal to splint, locally or in parts of the bed section. None appear to carry the percentage of ash usually found in block coal, excepting in the Warfield region.

The character of the product of the several beds with reference to specific commercial values cannot yet be given in

such detail as will be reached by the modern methods of testing in the practical use or by exhaustive laboratory studies.

The Warfield seam appeals to the observer as more constant in specific character than any of the beds above, but it will be noted that all are variable; perhaps nearly as much in the character of the coal as in the details of thickness and of benching by partings which must be rejected for the general market. The increase in the number of workable beds by thickening of thin seams or by the intercalation of beds, adds considerably to the coal resources southward in this field, as will be seen in the Poplar creek section.

The analyses available for giving an account of the coal of the Tug fork beds are usually such as have been made for the several mining companies by well known chemists. Samples taken under the direction of managers from the whole face represented. The unusual freedom from ash in some of the results of analyses will be remarked as probably less than the average from the personal bias of the miner in favor of the brightest chippings, but the several beds will also be noted by the unbiased observer who takes the time to examine them as now exposed in the Tug fork basin, as unusuallyy free from imbedded earthy matter.

The Warfield district is at the border of the Tug fork basin and it is not so evidently within this coking coal field. From the character of its coals as formerly mined, the Warfield seam showed a thickness of 60 inches with an upper bench of 54 inches separated from the bottom layer by a thin parting. The bed as a whole is splinty, with diffused thin earthy laminae, giving an increased per cent. of ash. A sample taken by the writer from two rooms (A) and another taken from the upper bench (B) showed the following results at the laboratory of the Survey:

		A		B
Specific gravity	1.302		1.351	
Moisture		2.00		2.16
Vol. com. matter		35.12		33.60
Fixed carbon		54.82		55.06
Ash		8.06		9.18
		100.00		100.00
Sulphur	0.983		0.745	

At the 300-foot level above the river (887 ft. A. T.) in the Warfield locality, a splint coal was formerly opened, having also a tendency to block structure, 43 inches thick. This is probably at the horizon of the Broas block, No. 5; and the Thacker seam up the river.

The results of analysis, by Dr. Robert Peter, of a sample taken by the writer from the whole face of the bed are as follows:

	Warfield 43-inch Seam.
Specific gravity	1.358
Moisture	2.50
Volatile combustible matter	33.70
Fixed carbon	52.62
Ash	11.18
	100.00
Sulphur	7.54

At Borderland, two miles above the mouth of Big creek, the three beds of commercial value are exposed below the Borderland seam. The Alma coal, 120 feet above the Warfield previously described, or at the 160-ft. level above low water, has the following bed section. Sandrock ledges are exposed above and below this seam.

	Inches.	Inches.
Roof, slate to s. s. above.		
Soft coal	50	....
Slate	....	1
Coal	10	....
Clay	....	2
Coal	3	....
	63	3

At the 260-foot level a 20-inch coal probably represents the Thacker seam. Above this coal, sandrock largely fills the interval to another thin coal, 75 feet higher in the series.

At the 410-foot level, is a bed 43 to 47 inches without parting, the lower half block coal. An entry driven in 30 feet under slate roof shows good body of coal, apparently at the

horizon of coal No. 7, as in the Whitehouse district. The Borderland seam under a massive sandrock bench near the 500-foot level has a thickness of 74 inches as measured at two headings.

This seam is in three benches of about 2 feet scarcely separated by more or less persistent layers of "mother coal." The results of analyses of this coal as given by the Manager, L. E. Armentrout, are as follows:

	Lower bench.	Middle.	Upper.
Moisture	0.68	0.79	1.49
Volatile combustible matter	35.96	36.48	33.34
Fixed carbon	61.40	59.50	60.41
Ash	1.51 reddish	2.62 white	4.19
Sulphur	.450	.610	.570
	100.000	100.000	100.000

Of the other beds no analyses are available. The upper bed as reported may be regarded as representing the Coalburg seam of the Williamson, West Virginia, section, supposed to be the Coalburg coal of the Kanawha valley.

The Burnwell section shows the order of beds as found in that district. The details of the beds are given in the vertical section. Records of developments in the neighboring hills were contributed by S. A. Beddall, Manager of the Burnwell mines.

An analysis of the Burnwell coal, the Warfield bed, by Prof. B. H. Hite, of Morgantown, West Virginia, of sample by Manager Beddall, gives the following results: Slaty 5 inches and slack not included.

Moisture	1.62	
Fixed carbon	57.72	Phosphorus, .003
Vol. com. matter	38.52	Sulphur, .540
Ash	2.14	B. T. U., 14700
	100.00	

The Alma and Thacker seams are here coking coals, and comparatively free from earthy sediment. The coal above the Thacker is the dirty or parting seam of the region, the 45-

inch bed of Borderland and the splint coal of the Buffalo creek section, W. Va.

The coal next above not seen by the writer is in the place of the Borderland seam, probably. Back in the higher region still higher coals are included, one reported by Mr. Beddall at the head of Stringtown branch, one mile below Burnwell, at the 750-foot level above the Burnwell seam (Bar), shows about 71 inches of minable coal. The Twin Knobs rise 320 feet above this level. Prominent coal stains on benches at the 650 and the 550 levels above the Warfield seam probably connect these horizons with the parting seam of the Burnwell section, and the Borderland seam 100 feet above.

The Pike Colliery seam is the Alma coal of this district, and at its maximum thickness as follows:

	Inches.	Inches.
Roof, bituminous slate to s. s.		
Coal, part splint	45	....
Shale and coal	....	6
Soft coal	18	....
	63	6

The elevation above tide is 1210 (Bar), the Railway grade at the mouth of Blackberry creek being 700 feet A. T. The mine is at the head of the Peter fork of Blackberry creek two and a half miles from the river.

Analyses of coal representing the whole bed and also the splint bench shows:

	Whole bed.	Splint.
Moisture	1.02	.860
Volatile combustible matter	37.11	36.66
Fixed carbon	56.51	56.22
Ash	5.36	6.26
	100.00	100.00
Sulphur	1.114	.715

The Freeburn Coal & Coke Co., operating at the mouth of Peter creek, are mining both the Freeburn coal (Warfield) and the Thacker seam. The former has been described at 1090

A. T. The Alma coal as opened on Hatfield branch, at 1200 A. T. (Bar.) and on Rockhouse fork at 1332 A. T. is as follows:

	Hatfield Br.		Rockhouse Fk.
Roof	Slate 4 ft. to s.s. above.		Sl. 12 in. to s.s.
Coal	27 in.	.... in.	55 in.
Clay	....	6	....
Coal	12	....	....
	39	6	55

The Thacker coal as mined in the hill to the left of Peter creek 230 feet above the Freeburn seam, 1320 A. T., shows locally two thin partings of fire-clay as below, from notes of Donald Clark.

	Inches.	Inches.
Roof, 3 feet slate to s. s.		
Coal	43	....
Fireclay	....	2
Coal	12	....
Fireclay	....	2
Coal	7	....
	62	4

This bed has been developed at a number of points in the Peter creek valleys. Representative bed sections are here given as descriptive of the bed and of its continuity in this region.

The Thacker bed.

	Rockhouse Fork.			Hatfield Br.	
	Lower Thacker.	Upper Thacker.			
	1437 A. T. (Bar)	1487 A. T.		1325 A. T.	
Roof	Bit. slate.	Slate		Sh. 6 ft. to s. s.	
Coal	66 in.	41 in.		51 in.	
Clay sl.			5 in.		Sl. 3½ in.
Coal		21 in.		15 in.	
Slate					1 in.
Coal				6 in.	
	66 in.	62 in.	5 in.	72 in.	4 in.

From analyses of the Peter creek coals made for the Freeburn Mining Company and for other parties as compiled by Donald Clark of Huntington, Manager of the Mason Coal & Coke Company, the following are selected. Analyses by Latrobe Connelsville Coal and Coke Co.

FREEBURN SEAM, MINE No. 4.

	Moisture and V. C. M.	Fixed C.	Ash.	Sul.	——Coke—— Ash.	Sul.
Pea slack	33.86	58.54	7.60	0.67	10.85	0.53
Slaty C. included	34.43	57.74	7.83	0.62	9.85	0.56
Slaty C. excluded	34.73	58.92	6.31	0.61	8.13	0.51

Whole thickness of bed 59 in. Slaty laminated part, 6 in. For coking the whole thickness would be used.

By Consolidated Coal & Coke Co., Fairmont, West Virginia.

	Moisture.	V. C. M.	Fixed C.	Ash.	Sul.
Freeburn Seam, Mine No. 4	1.80	32.32	62.82	3.26	0.83
Freeburn Seam, Mine No. 4, Coke	.30	.14	93.46	6.10	0.46
Lower Bench:					
Freeburn Seam, Mine No. 4	1.64	33.90	60.88	3.58	0.64
Freeburn Seam, Mine No. 4, Coke	.22	.42	93.26	5.10	0.58

By J. K. Anderson.—Peter Creek Coals.

	Moisture	V. C. M.	Fixed C.	Ash.	Sul.	Phosphorus.
Alma seam	0.162	35.24	57.43	6.71	0.55	.003
Freeburn seam	1.24	29.23	64.55	4.98	0.62	.....

By Mathewson. Freeburn seam, Laynes fork of Left Peter creek.

	Inches.	M. & V. C. M.	F. C.	Ash.	Sul.
Coal top	17	36.97	59.89	3.14	0.79
Coke top	17	1.73	94.05	4.22	0.42
Coal bottom	49	32.94	62.12	4.94	0.78
Coke	....	3.20	90.95	5.85	0.49
Slaty	7	31.00	52.75	16.25	0.46

The Vulcan Coal Company located one mile above the

mouth of Barren She creek has entries in both the Vulcan seam (Warfield) and the Thacker. The latter at 1459 A. T, is separated from the former by 259 feet, largely of cliff-forming sandrock.

The latter coal shows in detail:

Roof, 6 ft. or more shale to sandrock above.

	Inches.	Inches.
Coal	60	....
Clay shale	....	20
Coal	4	....
Fireclay, white plastic	....	48

The Alma coal was not examined at Vulcan.

Analysis and test by Norfolk & Western Ry. Company give the following results representing the Vulcan seam.

Moisture	1.24
Volatile combustible matter	29.23
Fixed carbon	64.55
Ash	4.98
	100.00
Sulphur	0.65
British thermal units	14665

The following are results of tests of these coals in West Virginia, Tug Fork region, as reported by Prof. I. C. White.

	B. t. u.
Average of 2 samples, Warfield seam, air dried	13909
Average of 4 samples, Alma seam, air dried	13998
Average of 6 samples, Thacker seam, air dried	13559

The working entries of Majestic mines on Poplar creek, two miles from the mouth at Cedar Station, are in the Warfield seam. The coals of the series above the Majestic Warfield bed are also exposed for examination, giving an interesting exposition of the order of beds in this district. See the Poplar creek section. The presence of the upper and lower Thacker beds as on the Left fork of Peter creek, which heads in this direction, will be noted; also the duplication of the Alma seam,

both of which features continue in the Hurricane-Turkey creek section. The parting seam above the Thacker level here offers a body of coal 85 inches thick with a parting slate of 2 inches only.

The beds above the Warfield (Elkhorn) seam are opened in the ridge at the heads of Turkey and Hurricane creeks, exposing beds as follows:

	Alma Coal	Upper Alma	Thacker Coal	Upper Thacker
H't above Warfield C. (1400' A. T.)	135' Bar	185'	250'	315'
Roof	Cl. Sl.	Sl.	SS.	Cl. and Sl.
Coal	36"	25"	49"	32"
Parting	.....	F. C. 5"	....	Sh. ½"
Coal	.....	13"	....	15"
Tolal thickness....	36"	43"	49'	47½"

These beds rise successively to the hill tops, some of which rise above the 1900-foot level A. T., and give place to the War Eagle beds as previously described in West Virginia.

Analyses by A. S. McCreath of samples collected by J. S. Silliman from the Warfield seam in the region drained by the Hurricane, Turkey, Camp and Pawpaw creeks show the character of this seam unchanged. The results obtained are given in the following table:

	M.	V. C. M.	F. C.	Ash.	Sul.
Grassy Fork of Pawpaw	1.38	30.38	60.32	7.40	0.51
Blankenship C. Turkey Fk.	1.45	31.94	60.67	5.39	0.53
Robert C. Turkey Fk.	1.45	33.11	58.60	6.23	0.60

The average thickness of this coal in this region as shown by six openings is 62 inches of coal and 6½ inches slaty coal or 68½ inches of bed section all of which should be utilized in coking for the market. Across the ridge on the waters of the Levisa fork, this bed is equally as prominent to the West Virginia line and beyond; rising to the tops of the hills, some of which reach the 1900-foot level above sea.

In the study of this field the work has been greatly facili-

tated by the aid received from Donald Clark, Manager of the Mason Coal and Coke Co., Huntington, West Virginia, both in the field and at his office; from George Dimick, who has personally directed the study of the coal oil resources of Eastern Kentucky for many years, by records of oil wells freely offered at his office in Cattlettsburg; by courtesies extended by W. A. Young, Manager of the Freeburn mines, Roger Martin, Manager of the Vulcan Coal Company, A. B. Rawn, Manager of the Majestic Mining plant, on Poplar creek, and by S. A. Beddall, Manager at the Burnwell mines. Also by L. E. Armentrout of Borderland and A. R. Paddock of the Pike Collieries in work of a former year. Not least, by D. J. Wollford and Mrs. Wollford, who made headquarters for the season a pleasant home retreat for the writer as a representative of the Kentucky Geological Survey, at their home near the mouth of Peter creek.

COALS IN THE CENTRAL CITY, MADISONVILLE, CALHOUN AND NEWBURG QUADRANGLES OF THE WESTERN COALFIELD

By F. M. Hutchinson.

Prof. Charles J. Norwood,
Director, Kentucky Geological Survey.

Sir:

I have the honor to submit herewith the following Summary Report on the Coal Resources of the Calhoun, Central City, and Madisonville Quadrangles, and on that part of the Newburg Quadrangle lying South of the Ohio river. These quadrangles include portions of Daviess, Henderson, Webster, McLean, Hopkins, Ohio, and Muhlenberg counties, in the Western Coalfield. The area included is about 800 square miles.

The Survey is indebted in many ways to the citizens of this region generally for their cheerful co-operation in furthering the work, and especially to Messrs. Hywel Davies, Shelby Gish, P. O. McKinney, James Halstead, R. W. Batsel, and W.

P. Robertson, all of whom contributed valuable information.

Respectfully,

F. M. HUTCHINSON,

November 30, 1909.

Central City and Madisonville Quadrangles.

Location.—This area includes parts of Ohio, McLean, Hopkins and Muhlenberg counties, and a very small portion of Webster county, and is bounded by parallels 37°15′ and 37°30′, and by meridians 87°0′ and 87°30′. The two quadrangles being divided by the meridian of 87°15′. The area inclosed is about 460 square miles.

Topography.—In its topography this area presents the characteristic features found in the interior portions of the Western Coalfield. As a rule the hills are low, flat-topped, or oval shaped, the slopes are gentle sandy, and much eroded, and the bottoms, particularly of the large streams, are broad and flat. The most rugged topography prevails in the Eastern and Southern portions of this area, being the result of a higher general surface and a correspondingly greater erosion. In the vicinity of Bremen, Sacramento, and Anton the general surface is low, but little erosion has taken place, and the country lays well for farming purposes. Elsewhere, the above general rule applies. The configuration of the hills has been largely influenced by the predominating incoherent sandstones. The broad bottoms are due partly to the lateral swinging of their streams, but chiefly to a depression of the land, which has caused these streams to seek a higher base-level, resulting in the filling up of the old valleys to their present height. The entire area is drained by Green, Pond, and Rough rivers and their tributaries. Green river is navigable the year round, and Rough river is usually navigable for a distance above its mouth for small craft.

Culture.—There are two small cities, namely, Madisonville and Central City, and several smaller towns, among which are Livermore, Sacramento, Island, Hanson and Slaughtersville lying within these quadrangles. The railroad facilities are excellent. The St. Louis, Evansville & Nashville division of the Louisville & Nashville Railroad traverses the Western edge of this area, the Owensboro & Adairsville division of the same system, crosses it North and South near the center of the Central City Quadrangle, the Memphis and Louisvillie division of the Illinois Central crosses the southeastern corner of the area, and the new Madisonville, Hartford & Eastern Railroad extends in an east and west line across both sheets near their centers. In some localities, as for example around Sacramento, Bremen, Anton, and Madisonville, the country is in a fair state of cultivation, but generally the farming lands are sadly neglected, especially in parts of Ohio and Muhlenberg counties. Hills and sandy slopes that could profitably be kept in grass are cultivated a few years after clearing, and then cast aside to the mercy of the elements, and new land cleared. As a result, erosion has been going on at a rapid pace, and the only remedy now is to plant in grass. By far the greater part of the rich bottom lands are low and somewhat marshy, and but little attempt has been made to drain them. A systematic draining of these areas would make available some of the richest farming lands in the country.

Rocks exposed.—The rocks exposed over the area lie wholly in the Coal Measures. The vertical distance from the highest to the lowest outcroping stratum is about 650 feet.

Structure.—The structure of the Central City and Madisonville Quadrangles is rather featureless and depends mainly upon the large syncline which crosses both quadrangles in an east and west line near their centers. The bottom of this syncline enters the Central City sheet from the east at a point almost due northeast of Ceralvo, whence it extends in an almost due western course and crosses Green river at Smallhouse, thence it passes half a mile north of Bremen, crosses Pond river three-fourths of a mile south of the mouth of Log

creek, passes one mile north of Anton, and leaves the Madisonville Quadrangle at a point about two and a half miles north of the city of Madisonville.* This syncline dips to the west at an average rate of 8 feet to the mile. From its center the rocks rise both to the north and to the south. Southward they rise rather uniformly at a rate varying from 50 feet to 70 feet to the mile. To the north, however, the upward slope differs materially over the two quadrangles. Over the greater part of the Central City sheet it will average 50 feet per mile, but westward from Cypress creek, and on the Madisonville sheet, the rate of slope is much less, varying from 10 feet to 20 feet per mile.

Another structural feature worth mentioning is a small anticline which enters the Central City Quadrangle at a point two miles west of Hillside, swings to the northeast, passing about one mile north of Graham, and from thence tends to the southwest, leaving the sheet at a point lying due south of Harps Hill.

Along the northern border of the Central City Quadrangle is a fault which closely follows the general course of Rough river, probably extending as far west as Bate's Knob, and possibly farther. The downthrow of this fault is to the north and is not less than 100 feet. Another fault, or probably an offshoot of this same fault, extends from a point near Bate's Knob southward for five or six miles along Cypress creek. Both of these faults are merely parts of the great Rough Creek Disturbance of which the main fault line lies a few miles farther north.

The Coals.

But little reliable information is now available concerning the coals which lie wholly below the surface. A few widely scattered well-records, and other data, demonstrate the presence of several seams, but the knowledge at hand is insufficient to determine their thickness or quality. A test well drilled one mile north of Central City gives the thickness of coal No. 8 there as being 7 feet, but this thickness is probably due to the heavy carbonaceous shale which immediately overlies coal No. 8.

*A fault which occurs a short distance north of Madisonville has doubtless been mistaken for the bottom of the syncline; the bottom is still farther north of Madisonville.—C. J. N.

Of the coals lying below No. 8 in this region, too little is known to afford the basis of an opinion as to their thickness and character.

There are nine known coal beds outcropping on the two quadrangles. In ascending order these are, No's. 9, 10, 11, 12, 13, 14, 14a, 15 and 15a. Of these, there are four minable veins, namely, No's. 9, 11, 12 and 14, the remainder usually being too thin for profitable mining, either locally or on a large scale.

Coal No. 9.—This coal, on account of its superior qualities and minability, and wider occurrence, is by far the most valuable coal outcropping on these quadrangles. It underlies the entire area with the exception of a narrow strip about three miles wide along the northern edge of the Central City sheet, where it has been carried away by erosion. Its outcrop area is limited, however, to the southern edge of both sheets, to the hills lying immediately south of Rough river, to the vicinity of Island Station, and to the isolated hills called Bate's and Bealer's Knobs in the northwestern corner of the Central City sheet. Elsewhere over this region this coal is under cover, due to the great syncline. At Moorman it lies about 300 feet below the valleys, and at Bremen, Sacramento, Anton, and Hanson it is respectively about 350, 300, 420, and 360 feet below the drainage lines. At Slaughterville the coal is about 290 feet below the general valley level. It reaches its maximum depth at a point about midway between Hanson and Madisonville, where the syncline leaves the sheet, being then about 450 deep in the valleys. From the center of the syncline the coal rises to the north and south as has already been explained. Its maximum and minimum thickness are 6 feet and 3 feet 10 inches respectively, though at only one point, namely, in the Davis Bank west of Island Station does it reach its minimum thickness, or become less than 4 feet. It is thickest along the southern border of the two sheets, having there an average thickness of 5 feet 3 inches, but gradually becomes thinner as it extends to the north, as is the case with most of the other coals, and along the northern border has an average thickness of 4 feet 4 inches. A fair average for the whole area is 4 feet 10 inches. It is a hard, bright coal, and is almost invariably free from partings. When washed

it gives a bright, firm coke with 1 per cent. of sulphur, but when not washed, the percentage of sulphur runs rather high. It is overlain by from 2 to 5 feet of black shale which forms an excellent roof. This coal is the best shipping coal in the Western Kentucky Coalfield, as well as being now the most saleable. There are seventeen large mines in this coal now in operation on these two sheets, besides a large number of country banks which are supplying the local trade.

Coal No. 10.—Coal No. 10 is a thin vein having little or no commercial importance in this area. It ranges in thickness from 1 foot to 2 feet 6 inches, with an average of 18 inches, and attains its maximum thickness in the vicinity of South Carrollton. Usually it is found wherever No. 9 is present, being very persistent. Its distance above No. 9 varies from 50 to 85 feet.

Coal No. 11.—Next to No. 9 this coal is the most valuable coal outcroping on this area. Its areal distribution is practically the same as that of No. 9, except that it has been removed by erosion from the hills surrounding Island station, and from few smaller areas, where No. 9 still exists. Like No. 9, this coal is also thickest along the southern border of the quadrangles, having an average thickness there of 5 feet 6 inches, with a maximum and minimum of 6 feet and 5 feet respectively. It also frequently becomes thinner toward the north, being about 4 feet 6 inches along the center of the sheets, and not more than 3 feet along their northern borders. The record of a coal test made one half mile north of Hanson gives the thickness there as being 3 feet 6 inches, and a record at Slaughterville shows a thickness at that place of 6 feet 6 inches, including a clay parting of 2 feet near the middle of the seam. The quality of this coal is good, though it is softer and does not ship as well as No. 9. Usually this bed is divided into three benches by clay partings, of which one lies 18 inches above the bottom and is about 1½ inches thick, the other lies one foot below the top and is about ½ inch thick. It makes good coke, having about 1 per cent. of sulphur. Its roof is excellent, being a hard, blue limestone from 3 feet to 5 feet thick. This coal averages from 70 feet to 134 feet above No. 9.

Coal No. 12.—This coal lies at an average distance of 12 feet above No. 11 and underlies practically the same territory. It is a pure coal, rather soft and generally free from partings of consequence. It is the best coking coal known in this region, making a bright, firm coke containing less than 1 per cent. of sulphur. It attains its maximum thickness of 5 feet 9 inches in the southwestern part of the Central City sheet, and has an average thickness of 4 feet 6 inches in all the region south of the new Madisonville, Hartford & Eastern Railroad. A number of small openings have been made over this area but the coal is usually overlain by soft shale which makes a bad roof, and when possible preference is given No. 11. Locally, however, a hard sandstone overlies the coal and it forms a good roof. North of the Madisonville, Hartford & Eastern Railroad the coal is generally of little value and in places is entirely absent. Test wells made at Hanson and at Slaughterville penetrated its horizon, but found no coal at all. The only known outcrop of this coal north of this railroad is at Point Pleasant, in Ohio county. At this place the coal is 5 feet thick, and is mined for local consumption. This appears to be a local thickening of the vein, however, for nowhere else in this region was it found to be more than three feet thick. Its average distance above No. 9 ranges from 82 feet to 146 feet.

Coal No. 13.—From a commercial standpoint this coal is of minor importance. It occurs generally over the region lying south of the Madisonville, Hartford & Eastern Railroad, but no knowledge was obtained of its existence north of this railroad. No openings have been made in this coal, but from reports of coal tests its quality is good. It lies at an average distance of 150 feet above No. 9.

Coal No. 14.—This coal locally is of considerable economic importance. It is the thickest coal outcropping in this area, ranging from 5 feet to 11 feet. Its horizon underlies about one half of the Central City sheet, and about two-thirds of the Madisonville. Its southern limit may be defined as following a line which, beginning two miles south of Madisonville, from thence extends eastward, crossing Pond river near the mouth

of Bratton creek, passes through Central City, and leaves the eastern edge of this territory about one mile south of Ceralvo. Its northern area of outcrop may be traced by a line passing near Centertown, through Matanzas half way between Stroud and Island station, and thence with Cypress creek to the northern boundary of this area. These outcrop lines nearly inclose the horizon of the coal, however, for the coal itself is of a pockety nature, and is not always found where its horizon indicates its existence. For example, in Robinson's shaft, located one mile south of Moorman, the coal was 7 feet 10 inches thick, whereas at Bremen, in a test made there, it was wholly missing. Again, near Browder church, which is situated seven miles east of Madisonville, it measures 11 feet thick, but it has thinned down to 2½ feet at Hanson, and is entirely absent at Slaughterville. It is constant, however, under the hills lying between Moorman and Central City, and in the region east of Green river. Over this latter area the coal averages 7 feet 6 inches thick, and there are numerous openings which supply the local market. Generally this coal is divided into two benches by a shale parting 20 inches above the bottom, this parting ranging from 1 to 4 inches thick. It burns well, the top bench being good for blacksmithing purposes. It is used extensively as a steaming coal by the Green River packets, being pronounced the best steaming coal on Green river. It makes but little clinker, and, so far as can be told without analysis, it contains but little sulphur. Its interval above Coal No. 9 is about 220 feet.

Coal No. 14a.—This coal is scarcely of any economic importance. It is not a persistent vein, having been found only in the vicinity of Smallhouse, and in the hills lying south of Semiway. In the latter locality an attempt has been made to mine the coal, but failed, the coal being thin, and, as is generally the case, largely mixed with shale. It varies from 3 feet to no feet in thickness, and lies about 310 feet above No. 9.

Coal No. 15.—This coal is a persistent vein, but its area of outcrop is small. It outcrops in the hills lying immediately east of Smallhouse, surrounding Moorman, and also in the

vicinity of Gishton and Hanson. As a rule it consist mainly of carbonaceous, sheety shale, with streaks of pure coal. In places, however, as for example in the railroad cut 1 mile south of Moorman, the coal has the thickness of 16 inches. Attempts have been made to mine it in this locality, as well as in a number of places near Smallhouse, but it was abandoned on account of its thinness. Its quality was found to be good. It is overlain with from 2 to 3 feet of carbonaceous sheety shale. Its average distance above No. 9 is 340 feet.

Coal No. 15*a*.—This coal is seen in a few places in the vicinity of Gishton, and around Hanson. It is a thin vein, usually being about 1 foot thick. It is overlain with soft shale, and lies about 370 feet above No. 9.

Coals above 15*a*.—In the region surrounding Hanson are two, perhaps three coals, of which the correlation is not yet clear. They are thin veins, however, and of little economic importance. The most important is the coal mined in Jack Epply's bank located 2½ miles southeast of Hanson. At this place the coal measures 3 feet thick without parting. It has a soapstone roof. No other banks are in operation in this region, but, in a few other places, this same coal has been worked, and attempts, which were always failures, have been made to mine the other veins.

The true position of these coals will doubtless be ascertained as the investigative work is carried westward, but the data obtainable in the Madisonville Quadrangle is insufficient to show their correct correlation.

Calhoun and Newberg Quadrangles.

Location.—The area treated in this report consists of all of the Calhoun Quadrangle and about two-thirds of the Newberg Quadrangle, and is limited on the north by the Ohio river, on the south by the 37°30′ parallel, and on the east and west by the meridian of 87°15′, and 87°30′ respectively. The two quadrangles embrace portions of Henderson, Daviess, McLean, Webster, and Hopkins counties, and are separated by the parallel of 37°45′. The area inclosed is about 380 square miles.

Topography.—The topography of this area does not differ materially from that found on the Central City and Madisonville Quadrangles. The Rough Creek Uplift has left but little impression on the surface forms, though some high hills southwest of Beech Grove, the highest on this area, are due to it. The highest hills, with this exception, are found mainly in the region surrounding Cleopatra and West Louisville, and, in the southwestern corner of the Calhoun Quadrangle, lying south of Anton. The region surrounding Baskett, Zion and Coraville consists of fairly level land, excellently adapted to agricultural purposes. The extent of fluviatile deposits in this territory, on account of a body of about 75 square miles of bottom land lying between Green and Ohio rivers, surpasses that existing on the Central City and Madisonville Quadrangles, but, as a rule, low, rounded hills, and rich valleys, precisely as found on those sheets, here also prevail.

Culture.—No large towns are situated in this area, though there are a number of smaller places, chief of which are Calhoun, Rumsey, Curdsville, Beech Grove, Spottsville, and Baskett, within its borders. The country is generally in a fair state of cultivation, though much valuable farming land is uselessly allowed to wash away. That portion of Henderson county lying west of Green river embraces most of the level upland, and, except when the bottoms have been systematically tiled, this region constitutes the best farming land.

The Louisville, Henderson and St. Louis Railroad crosses the northern portion of the Newberg sheet, and the St. Louis & Nashville line of the Louisville & Nashville system crosses the extreme southwestern corner of the Calhoun Quadrangle. Green river furnishes the chief avenue of commerce for the greater part of these sheets.

Rocks Exposed.—The outcropping rocks on this area, though fewer beds are represented, are practically a continuation of the same beds found on the Central City and Madisonville Quadrangles. The sole known exceptions to this rule are seen where some of the lower rocks, as for example an exposure of Sub-Carboniferous limestone on Eyra Ashton's farm,

3 miles north of Calhoun, have been brought to the surface along the Rough Creek Uplift. Elsewhere, however, the exposed rocks all belong to the Coal Measures, the vertical section including about 300 feet.

Structure.—The principal structural features appearing in this area are two faults, which are respectively named the Curdsville Fault, and the Rough Creek Uplift. Of these the Rough Creek Fault is by far the more important. It is a well known disturbance, which extends in an irregular line almost entirely across the State, passing through Shawneetown, Sebree, Leitchfield, and further east. Its character is not everywhere known, but that portion confined to this area is in the form of a great anticline, which, under the strain of excessive folding, has been faulted or broken, in many places, with displacements varying from a few feet up to more than 100 feet. The crest of this anticline, or more properly, the centre of the Uplift, enters this region from the east at a point about 4 miles north of Calhoun, passes through Beech Grove, thence trends slightly to the southwest, and leaves the western border of the Calhoun Quadrangle at Steamport Ferry. The disturbed region is fully 4 miles wide, and, within this space, only limited areas of regularly bedded strata may be expected.

While the folding process which resulted in the Rough Creek Anticline, was in progress, the rocks along its edges were likewise subjected to an enormous strain, and when this strain had become greater than the cohesive power of the rocks, a break resulted. The Curdsville Fault is due to such a break. It apparently begins at a point near Eastwood Ferry, and from thence, with a gradually increasing displacement, which varies from a few feet at its starting point to more than 100 feet at its northern limit, extends northeastward along Green river at least as far as the town of Birk. It is probably a simple displacement of which the downthrow is to the south.

South of the Rough Creek Fault the dip of the rocks is southward toward the Great Syncline, crossing the Madisonville and Central City Quadrangles, the rate of dip being about 15 feet per mile; between the Rough Creek Fault and the Curdsville Fault, however, the general dip is to the northwest

at an average rate of 25 feet per mile. Within this area is a small syncline of which the bottom extends in a northwest and southeast line through Jolly P. O. North of the Curdsville Fault the rocks fall away to the west at a rate which varies from 15 feet to 20 feet per mile.

Coals.

No reliable data at all were obtained in regard to coals lying wholly below the drainage lines. From information obtained in other regions it is probable that a number of the lower coalt are present in this area, but nothing positive can be said in regard to their number, thickness or quality, and the drill alone can obtain this knowledge.

There are three known veins outcropping over this area. In ascending order they are Nos. 9, 11 and 12. Of these No. 9 only, except in local areas, has a reliable, minable thickness.

Coal No. 9.—This valuable coal has been removed by erosion from Green and Ohio river Bottoms, but with this exception, it underlies all that portion of Henderson, Daviess and McLean counties included within the Newberg and Calhoun Quadrangles, and lying north of the Rough Creek Anticline. In Henderson county it has an average thickness of 4 feet; in Daviess and McLean counties its average thickness is quite 4 feet 6 inches. Its quality here is generally good, varying so little from the usual type as found on the Central City and Madisonville sheets, that only a chemical analysis can show any difference at all. Commercial mines are in successful operation at Baskett, Spottsville, Bluff City, and Utopia, and many small mines, as at Zion, Coraville, West Louisville, Cleopatra, etc., which cater solely to the local market, do a flourishing business.

At Zion the coal is 115 feet deep, at Baskett 135 feet, at Spottsville 60 feet, and at West Louisville about 80 feet deep. It is drifted for near Cleopatra. In these areas the coal is invariably overlain by the characteristic carbonaceous, sheety shale, this shale forming a most excellent roof.

This coal is also found in certain small localities included

in the faulted area of the Rough Creek Uplift, but where found is usually so badly disturbed as to render successful mining on a large scale a matter of apparent impossibility. Various small banks supply the neighborhood trade, however, as, for example, in the hills southwest of Beech Grove.

The horizon of this coal also underlies those portions of Webster and Hopkins counties lying in the southwestern corner of the Calhoun Sheet, but there is some doubt as to the continuous existence of the coal itself. A test made at Slaughterville, which is situated half a mile south of the southwest corner of this sheet, found the coal to be 4 feet 6 inches thick and 300 feet deep, but a similar test at Anton naturally raises a doubt as to the existence of the coal in that vicinity, but it is needless to say that one test is insufficient to prove the facts one way or the other. The fact that No. 9 is so remarkably persistent everywhere else is a strong indication that it also exists under all this region, but further tests will have to be made before the truth is ascertained.

Coal No. 11.—This coal does not attain to minable thickness over these quadrangles except in limited areas. Its horizon may be traced, however, even where the coal is wholly absent, or exists but as a trace, practically wherever No. 9 is found, by the persistent and closely overlying limestone. In the region around Beech Grove and Delaware, and also in the vicinity of Coraville, the coal reaches a thickness varying from 18 inches to 30 inches, the average being 24 inches, and has been opened in a few places. It reaches its maximum thickness in the hills lying southeast of Hebbardsville, being there 3½ feet thick. At no other known point in this area, however, is it present in commercial thickness. Its quality is very good. Its average distance above No. 9 varies from 78 feet to 88 feet.

Coal No. 12.—This coal has but little economic value on these quadrangles. It is very persistent, however, and its areal distribution varies only an insignificant amount from that of No. 9, which has already been described. It reaches its maximum thickness in the vicinity of Anton, being there 3 feet 6 inches thick, and a number of small banks have been operated in this region for the benefit of the local trade. It has also been mined in a few places around Jolly P. O., and near

Delaware, and between Coraville and Hebbardsville, its thickness in these localities ranging from 18 inches to 30 inches, with an average of 24 inches. Its quality is good, and its roof is generally a soft sandstone. It lies at an average distance of 94 feet above No. 9.

Coals above No. 12.—Two small coals, which are probably Nos. 13 and 14, appear in the southwestern corner of the Calhoun Quadrangle, but neither is of commercial importance. The thickness of each usually ranges from 6 inches to 12 inches, with a maximum of 18 inches. No attempts have been made to mine these veins.

Ohio River Bottom

The depth of the alluvial accumulations in the broad, flat bottoms lying between Green and Ohio rivers is at least 125 feet, and probably varies from 125 feet to 150 feet. To that depth at least it is certain that no coal exists; and since the horizon of No. 9 lies from 25 feet to 75 feet above the bed of this old erosion channel, it is certain that this coal and, of course, all the higher coals, are wholly ab, sent. The beds below No. 9, however, should not have been affected by erosion, and unless precluded by other agencies, should still be present. The only available, direct evidence bearing upon this subject is obtained from the record of a well drilled at Newman. This well was sunk to a depth of 1,200 feet, but found no trace of coal. The evidence, therefore, points to the fact that no coal exists under these bottoms, though, in an area of this size, one test, whether favorable, or unfavorable, could, of course, not be regarded as conclusive proof, either one way or the other. In this case it is highly improbable that all of the lower coals could so suddenly have been "wedged" out, and it is quite possible that some, at least, are present. There are no stratified rocks in this region, however, so the solution of the problem rests not with the geologist, but with the drill.

GENERAL SECTION.
FOR CENTRAL CITY AND OTHER QUADRANGLES.

		Thickness. Feet.
1.	Sandstone; soft, sometimes shaly; light brown; average thickness 30 feet; thickness varies	20-40
2.	Shale; sandy, brownish blue; average thickness, 8 feet	5-10
3.	Coal, 15a. Mainly carbonaceous shale, with streaks of coal; average thickness about 18 inches; varies	1-2
4.	Clay, blue; average thickness, 5 feet; varies	4-8
5.	Sandstone; soft, shaly at bottom; coarse grained, yellow, average thickness, 30 feet; varies	30-40
6.	Shale; carbonaceous, sheety; thin bedded, black, but weathering a dark blue; average thickness, 2 feet; varies	1½-2½
7.	Coal, 15. Hard, sometimes pure, sometimes shaly; average thickness, 1½ feet; varies	1-2½
8.	Fireclay and shale; blue; average thickness, 8 feet; varies	6-10
9.	Sandstone; coarse, soft, reddish brown, merging at bottom into soft, blue sandy shale	35-50
10.	Coal, 14a. Impure, not persistent; usually black shale	0-4
11.	Clay	2-3
12.	Limestone; generally in two ledges, of which the upper is about 46 inches thick and the lower 18 inches thick; very hard; steel blue on fracture; weathers into massive, irregularly-shaped boulders from 4 to 8 feet across, and of a dingy yellow color; has a granular fracture; fossiliferous	4-8
13.	Clay; heavy, light blue; makes excellent tiling	8-12
14.	Sandstone; sometimes hard, forming cliffs; sometimes soft and shaly; coarse grained, light brown	40-50
15.	Shale and "soapstone"; sometimes sandstone; soft, blue	8-12
16.	Shale; carbonaceous, soft	2-2½
17.	Coal, 14. In two benches with slate parting from 20 inches to 4 feet from the bottom; upper bench "peacock" coal, soft, makes little clinker, and has little sulphur	5-11
18.	Fireclay, blue	2-4
19.	Sandstone; usually coarse, light brown, incoherent	40-60
20.	Shale; sandy, varicolored; sometimes reddish sandstone	20-30
21.	Coal, 13. Pure, hard, bright	½-2½
22.	Clay, blue	2-3
23.	Sandstone; incoherent, coarse; brown with reddish streaks. At base of this sandstone silicious hematite is sometimes found, showing a thickness of 12 to 36 inches.	20-30
24.	Coal, 12. Bright, clean, but little sulphur; sometimes has a clay parting of 2 inches at 2 feet from bottom, but usually free from partings; rather soft	3-5½
25.	Clay, blue	3-6

		Thickness Feet
26.	Limestone; hard, blue on fracture; weathers a dull gray; usually in one large ledge, but sometimes in two or more; rich in fossils, especially crinoids	3-6
27.	Clay; sometimes hard, calcareous shale, known as "gob"	0-1
28.	Coal, 11. Bright, pure coal; ½-inch clay parting 1 foot below the top; 1½-inch clay parting 18 to 24 inches above bottom; bottom bench of coal has sulphur balls in it	3-6½
29.	Clay, light blue	3-5
30.	Sandstone; white, hard	25-35
31.	Coal, 10. Hard, pure	½-2½
32.	Sandstone; hard, grayish white, fine grained, cliff-forming; sometimes silicious blue shale	50-70
33.	Shale, gray	10-20
34.	Shale; carbonaceous, sheety, hard; sometimes contains limestone concretions of varying size	2-5
35.	Coal, 9. Pure, hard, bright, without parting; 46 inches to	5½
36.	Fireclay, blue	3-6
37.	Shale; sandy, blue	0-15
38.	Limestone; pure, soft, easily disintegrated; blue on fracture, weathers a bright yellow	1-2
39.	Sandstone; shaly, coarse grained, light brown	20-30
40.	Shale; blue, sometimes silicious	10-20

OIL, GAS, AND ASPHALT ROCK, IN MEADE AND BRECKENRIDGE COUNTIES

By Aug. F. Foerste.

About twenty years ago the inhabitants of Meade and Breckenridge counties took considerable interest in the drilling of wells for the purpose of securing natural gas. Within a few years over a hundred wells were sunk in Meade county and in the immediately adjacent part of Hardin county. Of these, the productive wells were confined to the territory between Brandenburg and West Point, nowhere extending beyond three miles south of the Ohio river. As a matter of fact, no systematic attempts to test the possibilities for gas were made outside of the limited area between Brandenburg and

West Point. Possibly ten wells were sunk in the outlying territory and none of these proved remunerative.

Several factors favored the development of the territory between Brandenburg and West Point in preference to the more southern and western parts of Meade county. The chief of these was the possibility of reaching the gas bearing strata at much less expense, although the greater proximity of this territory to the natural market, Louisville, also was an important factor.

The gas was obtained in the Black Shale, forming the upper part of the Devonian section of the rocks of Kentucky. Along the river bottom lands within a mile of Brandenburg, this Black Shale could be reached by wells about 500 feet in depth. At Long Branch, about four miles east of Brandenburg, wells between 400 and 425 feet in depth were sufficient. At Rock Haven, the Black shale was struck at about 360 feet below the river bottoms. About two miles east of Rock Haven, it was reached at 325 feet; and at West Point, at about 270 feet.

From this it is evident that the level of the Black Shale rises eastward and dips westward. In consequence of this westward dip the Black Shale is not struck at Richardson's Landing, a mile above King's Landing, and six miles west of Brandenburg, until a depth of about 800 feet is reached. It is calculated that at Concordia, in the western edge of Meade county, a depth of 1120 feet would be necessary to reach the Black Shale. Southwestward, along the Ohio river, this depth increases. At Stephensport, in the northwestern part of Breckenridge county, the Black Shale was struck at a depth of 1234 feet. It is estimated that at Cloverport a depth of about 1250 feet would be necessary.

From this it is evident that even if gas could be obtained from the Black Shale horizon in the territory west of Brandenburg, the wells bored east of Brandenburg would be more remunerative, and the latter territory would be exploited first. The expense of drilling a well naturally increases in a much greater ratio than the depth.

If the drilling were begun not in the river bottoms but upon the hill tops, the necessary depth of the well would be in-

creased by an amount equal to the height of the hill. Since the hills along the Ohio river in Meade and Breckenridge counties are frequently 200 feet in height, and the surface rises to 300 feet above the river bottoms within two or three miles of the river, the expense of reaching the Black Shale horizon rapidly increases. The result has been that up to date little attempt has been made to test the Black Shale horizon west or south of the Brandenburg-West Point territory.

The dip of the Black Shale has not been determined with accuracy. West of a line connecting Concordia with Hardinsburg, the dip is chiefly westward. East of this line, for a short distance, the dip is a little north or west. Along the line connecting King's Landing with Harned, the dip is estimated as approximately twenty degrees north of west. Farther east the dip has not been worked out very well, but is known to be westerly. Between West Point and Stithton, it appears to be south of west.

The rate of dip between West Point and Brandenburg is about 20 feet per mile westward. This dip is not equally distributed. Between the Bickerstaff wells at Long Branch and Brandenburg, the dip is 35 feet per mile westward, and then for a short distance east of the Bickerstaff wells the dip is about 10 feet per mile in the opposite direction, eastward. In other words, there is a small arch or incline at Long Branch, whose axis probably extends across the Ohio river in a direction a little east of north and from which the strata dip east and west. This arch has been called the Davis arch, after Mr. W. J. Davis, who first recognized its presence. Between Long Branch and West Point the dip is about 17 feet per mile westward. From this it is evident that the Davis arch is merely a local flexure interrupting the general westerly dip of the strata in this part of the county.

Although the Davis arch is a flexure of only small dimensions, its presence appears to have favored the accumulation of gas in the vicinity of Long Branch. Whenever water and gas are present in the same strata, the gas tends to rise above the water level, and wherever the strata are bent into the form of an arch, the gas tends to rise toward the most elevated part of the arch, toward the axis. If any of the overlying strata

consist of clay, or other comparatively impervious material, the rise of the gas is checked at the clay layer, and tends to accumulate along the axis of the arch just beneath the clay layer.

It happens that in Meade, Breckenridge, and other counties of Western Kentucky, the Black Shale is directly overlaid by a clay horizon, known as the New Providence clay shale in Indiana. Beneath this clay shale, the natural gas has accumulated along the Davis arch, and that is why the wells of the Brandenburg-West Point area must be drilled through the New Providence clay shale horizon, into the Black Shale, in order to tap the accumulations of natural gas.

Since the Davis arch is of small width and height, the amount of accumulation of gas beneath the New Providence clay shales of this arch is comparatively small, and this supply can be readily exhausted. As a matter of fact, this exhaustion has already begun. Pumping is necessary to keep the wells free from water, and during the summer of 1909 pumping was observed at only two wells, along the line between the Bickerstaff and Baskett farms, at Long Branch. At these wells, the pressure appeared to be low. The difficulty of securing reliable information from those most directly concerned in the exploiting of this natural gas supply is very suggestive of an insufficient supply, since a company supplied with an abundant supply of gas need not fear publicity.

Since the Black Shale dips toward the West, it must rise toward the East. Sooner or later it must crop out at the surface of the ground. As a matter of fact, the Black Shale outcrops along a belt crossing the middle parts of Jefferson and Bullitt counties in an approximately north and south line. Along this line of outcrop no natural gas could be expected, since the cover of New Providence clay shale has been removed and the gas may escape freely. Even for a considerable number of miles west of the line of outcrop, the conditions would not favor any considerable accumulation of gas, especially in the absence of any distinct arch of considerable dimensions. The eastward rise of strata favors the escape of the gas from beneath cover.

One of the earliest wells drilled in the Brandenburg-West

Point field is located on the Moreman farm, about a mile east of Brandenburg. This well was bored in 1863. The gas, as elsewhere in this field, is accompanied by salt water. For a number of years, the gas was used in evaporating the water and thus securing the salt. At first only five barrels a day was secured, but, at $5.00 a barrel, it paid. Later, when by improved methods the yield had been increased to twenty-five barrels a day, the price sank to 50 cents, and even to 45 cents a barrel, and finally the work was abandoned. In the meantime the pressure of the gas had decreased considerably. Similar salt works, started two miles northeast of Rock Haven, also are abandoned at present.

At present, the only wells actually in use are in the possession of a company engaged in supplying the citizens of Louisville with gas for heating purposes. In addition to this, the company controls other wells in the immediate vicinity, which it no longer utilizes.

Since the heating company supplying gas for fuel purposes to the citizens of Louisville is at present the only company utilizing the gas, private enterprise is not tempted to exploit the field any farther. Gas might be secured, but it could be sold to the Louisville company only at its own terms. A second company, interested in the same project, has found it impossible to secure the right of way to Louisville under any conditions which would make the enterprise profitable. Brandenburg and West Point might use up some of the gas, if further drilling discovered additional productive wells, but these towns are small and the prospect is not alluring. Possibly the Kosmos Cement plant, along the Ohio river a number of miles northeast of West Point, could make use of natural gas in sufficient quantities to make the field profitable, if it could be revived. The distance to which it would be necessary to convey the gas would be much less and the expense for this part of the service would be less.

In Breckenridge county, gas in paying quantities was discovered at Cloverport, on the Ohio river. Twenty years ago a dozen wells were in existence, practically within the town limits. A number of these wells were productive. Originally the pressure was good, but in recent years the pressure went

down to such an extent that the wells were practically abandoned for a time. At present, three of the wells are in use. At the tile works, in the eastern edge of the town, there is enough gas to run two boilers. The pressure here is about 65 pounds. The well along the river bank, immediately west of the mouth of Clover creek, has a pressure of 55 pounds, and produces whatever gas is used in Cloverport at present. This gas is utilized only in the western half of the town, west of Clover creek. Another productive well occurs about a square farther west, also on the river bank, behind the Mill. The pressure here is considerably less than 55 pounds, but pumping operations are continued, and this relieves the neighboring wells of water. When pumped out, the gas supply is fair. When pumping is stopped, the water soon drowns out the gas. The overload of water is too great for the gas to lift with facility, and the gas practically stops flowing. A well, seven squares south of the mill, once furnished considerable gas. Another, two or three squares south of the depot, on the eastern bank of Clover creek, once was a good well, but now is covered with water.

The recent revival of interest in these wells is due to Mr. Otto Tague. This gentleman has illustrated the value of expert knowledge in propositions of this nature. A field, once abandoned, has been converted into a source of modest revenue. Several wells have been freed from water, and properly connected with the mains. The pressure has been adjusted so as not to endanger the premises of the citizens using the gas. A part of the gas is utilized to illuminate the streets of the town. Eventually, it is intended to open up several additional wells, long abandoned, and to connect also the eastern half of Cloverport with these wells. It is intended to drill several additional wells. Should the hopes of the company now controlling the wells be realized, there might be sufficient gas to supply Hawesville, a small town, in a direct line about 8 miles northeast of Cloverport.

Both the well behind the grist mill and the well at the tile factory had not been used for about two years. After water had been pumped from the well from behind the grist mill for 30 days, the pressure rose to 65 pounds, but began to drop as

soon as pumping operations were discontinued. The well at the tile factory has recently been cleaned out and recased. The well at the mouth of Clover creek, the income of which had been reduced to $15 a month, under present conditions supplies a revenue of $150 a month. A contract has been made to supply 50 gas lamps for illuminating the streets of Cloverport at $1,000 per year.

The depth of the wells at Cloverport is about 900 feet. Since the Black Shale horizon at Cloverport is estimated to lie about 1350 feet below the level of the town, it is evident that the source of the gas at this locality must be from a considerably higher horizon than the Black shale. This source is either in the lower part of the St. Louis limestone, or in the upper part of the Keokuk formation. Judging from the records of the Stephensport well, this horizon at Cloverport belongs to the lower part of the St. Louis limestone formation. However, several speciments of rock said to have been obtained from one of the wells more closely resembles the rather coarse-grained limestone forming the underlying Harrodsburg limestone horizon. Only a continuous series of samples, such as that secured from the Stephensport well, can definitely determine the exact geological horizon.

If the Harrodsburg horizon has not been attained, in the Cloverport wells, it would be advisable to continue drilling until this lower horizon was reached. A coarse-grained limestone, such as the Harrodsburg limestone, if sufficiently thick, is likely to prove a better reservoir for gas that a finer, denser grained limestone, such as the St. Louis limestone.

The horizon at which the gas at Cloverport is found is approximately 450 feet above that at which the gas in the Brandenburg-West Point area occurs. Since none of the wells at Cloverport reach the Black Shale horizon, this estimate evidently is based on a comparison of various intermediate sections, chiefly that of the Stephensport well.

If the upper part of the Harrodsburg limestone serves as the reservoir for the gas at Cloverport, the very fine-grained limestone forming the St. Louis formation may serve as the cover. Between the Harrodsburg limestone and the St. Louis limestone, however, in Northern Kentucky and Southern In-

diana, is a clayey horizon, the Atherton bed. This bed belongs above the typical Salem limestone, which in Indiana is found immediately above the Harrodsburg limestone. The order of succession of these strata, in descending order, is:

St. Louis limestone.
Atherton bed, chiefly clay.
Salem limestone, of Indiana.
Harrodsburg limestone.

The Salem limestone is an important formation in the central part of Indiana, but it thins out southward to only two to four feet along the Ohio river. It has not been recognized in Kentucky. The overlying Atherton bed, however, carrying about the same fauna, is well represented in Northern Kentucky, but thins out before reaching Central Indiana. This Atherton clay bed may furnish the dark rock immediately overlying the coarse-grained Harrodsburg limestone of the Stephensport section. If present at Cloverport, it would serve as a cover beneath which the gas would accumulate.

If those interested in gas and oil wells were to preserve well labeled samples of their well drillings, taken every ten or twenty feet, a great part of the guessing made necessary under present conditions would be unnecessary, and underground geology could be placed on a much securer footing.

The conditions which favored the accumulation of gas in the Cloverport area appear to have been a small local flexure, similar to the one near Long Branch, in the Brandenburg-West Point area. The top of the limestone layer, which at Cloverport occurs about 30 feet above the level of the railroad, is found at railroad level at the Little Tar Spring, about two miles west of Cloverport. This is a westward dip of about 15 feet per mile. The westerly dip probably continues at least for several miles west of the Little Tar Spring, although the river takes a directly northward course. Hence, the top of the limestone exposed above the railroad level at Cloverport reaches river level a short distance below the mouth of Millstone creek, on the Indiana side of the Ohio river.

About four miles East of Hawesville, a fault appears to

bring the basal sandstone and conglomerates of the Coal Measures down to railroad level. On the Indiana side of the Ohio river, this basal Coal Measure conglomerate is found more than a hundred feet higher up, near the top of the hills.

Southeast of Cloverport, there is a dip toward the southeast. This dip may be determined along both roads to Harrodsburg, the one north of Clover creek, and the one south of this creek. The dip amounts to about 30 feet within half a mile, toward the southeast, and then for another half mile or mile the strata are approximately horizontal.

These facts suggest the presence of a local flexure of the strata in the western part of Breckenridge county, forming a small arch with its axis at Cloverport. As in the case of the Davis arch, no great accumulation of gas can be expected here, although careful conservation of all the gas supplied by the various wells might yield considerable revenue on an economical basis of expenditure.

In general, the strata in the western part of Breckenridge county dip westward. Between Hardinsburg and Cloverport, this dip averages about 26 feet per mile. Locally, this dip varies considerably in direction and amount, indicating that local flextures occur also in the intermediate area. A fault, of only moderate proportions, was noticed about four miles southeast of Cloverport, along the western end of the road connecting the two roads leading to Hardinsburg.

In case of both the Cloverport arch and the Davis arch near Long Branch, the western flank of the arch presents a long westward dip, while the eastward dip of the eastern flank is short. Possibly the source of supply of gas in both cases lies toward the west of the axis of the arch, and the flexure merely retards the escape of the gas eastward. The water in the depression east of the axis, where the eastward rise of the strata forming the arch is resumed, may act as a sort of plug, retaining the gas to a certain extent.

This question of the original source of the gas is of interest since it may be connected with the question as to origin of the oil and so-called tar products found in various parts of Breckenridge, and in some of the neighboring counties.

As far as the data so far accumulated may indicate, no ac-

cumulations of oil in any large proportions are to be expected in Breckenridge, or in any of the immediately adjacent counties. It is very unsafe, of course, to make any predictions, since the entire history of oil well digging appears to be a succession of discoveries of valuable reservoirs of oil at most unexpected places, but the evidence so far accumulated does not give the prospector great encouragement in the area under discussion.

Nevertheless, small accumulations of oil have been struck at various localities, and these accumulations appear to increase in number and quantity toward the west.

In 1889, a well was drilled immediately east of Hawesville, for gas. At a depth of 1230 feet, oil was struck. Since gas, and not oil, was wanted, drilling continued down to a depth of 1500 feet. By this time about $3750 had been expended, and no signs of gas in paying quantities had been discovered. Discouraged in the search for gas, the well was filled up to the level at which oil had been struck, and then was shot. The flow of oil increased. A tank for receiving this oil was built in the immediate vicinity. The oil was used for lubricating purposes. The amount shipped was somewhere between 50 and 100 barrels, and the total supply obtained amounted to about 200 barrels. A number of years were spent in slowly developing this well, and most of the pumping of the oil was done in 1895, or 1896. A second well was begun in 1893. The boring was discontinued at a depth of 900 feet. A third well was begun in 1904. At a depth of 300 or 400 feet, the drill got struck, and the well was abandoned.

About four miles east of Hawesville, on the Indiana side of the Ohio river, oil was struck at the home of Mrs. Mason, just above the mouth of Deer creek. At present no reliable data are obtainable, but it is known that the supply amounted to a number of barrels, and that more could have been obtained. Gas, not oil, was wanted.

In the absence of samples from the wells at Hawesville and at the mouth of Deer creek, it is not possible to determine at what horizon oil was struck at either locality.

Tar Spring is located about three miles directly south of Cloverport. Here the water rising from beneath the Tar Spring

sandstone carries with it a small quantity of oil, associated with which is the dark-brown, sticky substance that has given rise to the name, Tar Spring. It is evident that this so-called tar is the residual part of the oil after the more volatile parts of the oil have evaporated. To that extent, it indicates the presence of oil in the vicinity of Cloverport. A similar spring, known as the Little Tar Spring, occurs along the railroad track, about two miles west of Cloverport.

The source of this oil is unknown. The sandstone may be serving as a reservoir, rather than as an original source of the oil. Near the line of outcrop of this standstone, not much oil could be expected. Wells should be sunk a considerable distance west of the line of outcrop, where this sandstone is well under cover of the overlying clays.

At Cloverport, the base of the Tar Spring sandstone occurs about 30 feet above the level of the railroad. About 70 feet below the level of the railroad at the same locality, the top of the Garfield sandstone should be found. About two miles south of Garfield that sandstone has become so thoroughly impregnated with the more solid parts of the oil that the sandstone has been converted into an asphalt rock. Oil must have seeped through the sandstone for long ages, losing the more volatile parts by evaporation toward the surface of the line of exposure. Such an accumulation of asphalt can be regarded only as a residual product, from oil. The local distribution of this asphalt suggests that the sandstone may have served merely as a channel along which the oil seeped gradually upward. The same original source may have supplied both the Garfield and the Tar Springs sandstone.

The Garfield sandstone is separated from the underlying Big Clifty sandstone only by a comparatively thin limestone bed. In Grayson county, both east and west of Leitchfield, the Big Clifty sandstone is impregnated locally with asphalt.

The fact that the asphalt is already mixed with sandstone suggested twenty years ago the advisability of trying the rock as a road metal. It appeared to serve this purpose very well, but the commercial success of the enterprise was not encour-

aging,* and for many years, the so-called asphalt mines of Garfield have remained idle, and those of Grayson county appear to be about ready to suspend operation.

Occasionally, a little oil has been found in the wells drilled for oil in Meade county.

West of Cedar Grove church, about a mile south of Weldon, an oil well was sunk in 1888. A rather poor flow of gas was reached at a depth of 719 feet. This well was cleared out near the close of 1908. At about 860 feet, salt water was struck, and this rose to a height of 300 feet in the well. The quantity of this water, however, was small, so that the well was easily kept dry by bailing. The bottom of the Black Shale was said to have been reached at a depth of 934 feet. This may be true, since at a depth of 973 feet, salt water rose in large quantities, to a height of 180 feet from the top of the well, causing the abandonment of further drilling. Since this water appeared to come from a rather coarse grained limestone, apparently from the upper part of the Devonian limestone horizon, the rock at 943 feet may have been from the basal part of the Devonian Black Shale. Those engaged in drilling the well thought they had reached the top of the Black Shale at 700 feet. This would give a thickness of 243 feet to the Black Shale, an amount believed to be in excess of the facts. At a depth of 755 feet, a gritty layer was struck, yielding a slight increase in the flow of gas and a small quantity of oil. Although the rate of flow of this oil was very slow, it finally rose to a height of 400 feet above the bottom of the well. Two more of these gritty layers were struck at lower levels, in going through the so-called Black Shale. The upper gritty layer evidently consisted of a coarse-grained limestone, since it dissolved readily in hydrochloric acid. Its horizon probably was in the lower part of the New Providence clay shale, instead of in the Devonian Black Shale. This may have been true also of the underlying gritty layers, whose exact horizon has not been recorded.

Recently the well on the farm belonging to Jack and Harry

* Which, however, was in no way related to the character of the material, or its fitness for road-making.—C. J. N.

Herrington, about two and a half miles south of Weldon, was noticed to have 3 or 4 inches of oil on top of the water which gradually had filled the well. After removing the oil, it gradually accumulated again. This well had originaly been a gas well, sufficient gas having been obtained to supply the house. The well was drilled in the eighties.

Similar discoveries of small quantities of oil at other wells encouraged some of the citizens of Meade county to make an attempt to secure oil, in place of gas. It was hoped that this oil might be obtained by going beneath the Black Shale, into the so-called sand which had been reached in the Weldon well. This so-called sand was merely the coarse-grained limestone beneath the Black Shale, but the term sand is used by oil drillers indiscriminately for any coarse-grained rock, apparently presenting a loose texture.

Knowing that oil, like gas, tends to rise towards the top of anticlines or arches in the rock, the citizens interested in the oil well project made search for an anticline, and came to the conclusion that the conspicuous hill ridge two miles south of Ekron, was produced by such an anticline, that the presence of the high hill was in itself an evidence of the presence of such an anticline. While this line of reasoning is entirely incorrect, it happens, as a matter of fact, that a small anticline is present in the region traversed by the ridge, but this anticline is small both in height and in width, and does not give promise of yielding any great supply of oil, even if any should be discovered. It is merely a local flexure in the general westward dip of the rocks of this part of the county, comparable with the local flexures at Long Branch and at Cloverport. Believing that the hill itself was the anticline, the well was started on the very crest of the hill ridge, thus unnecessarily adding about 300 feet to the depth of the well to be bored. It has not been found possible to secure reliable information from those engaged in this enterprise, and no oil had been discovered when the territory was last visited, late in the summer of 1909.

If all the facts which have been revealed by the drill during the last twenty years could have been made available, the work of drilling for gas or oil could have been placed upon a much more intelligible basis. The geologist can learn some-

thing from exposures as they occur at the surface. Often he is driven to form conclusions from facts derived solely from this source. But it is evident, that the driller is interested chiefly in the geology of the strata not exposed to view, hundreds, and even thousands of feet beneath the surface. If all the facts, derived from all the wells could be collated, underground geology by this time would be on a rather fair footing. The tendency on the part of drillers to conceal the facts simply prolongs the days of comparative ignorance. Ignorance on their own part as well as ignorance on the part of others. The rights of the prospector are protected sufficiently well by his leases. The ultimate result of the secrecy observed by many drillers results frequently in the concealment of ignorance rather than in the accumulation of information. The numerous associations among men engaged in other lines of business illustrate the fact that a comparison of the experience secured by many men in the same line of business is helpful to the entire fraternity. This lesson has not yet been learned by many of those engaged in prospecting for oil.

A number of references have been made to the well at Stephensport. This is the only well in Meade and Breckenridge counties from which a consecutive series of samples appears to have been collected in an intelligent manner. As a result, more has been learned from this single well than from any of the remainder. The following notes will present some of the chief features of this well record.

Limestone fragments, 22 and 30 feet beneath the surface of the ground at the opening of the well, indicate the presence of a layer of limestone below the Garfield sandstone, and above the Big Clifty sandstone.

Fragments of the Big Clifty sandstone were struck 35 feet below the surface.

Fragments of Ohara limestone were brought up from levels 48, 67, 75, 85, 130, 135, 155 feet below the top of the well. Some of this limestone was coarsely grained, especially toward the top. Some of it was fine grained. Toward the base, sandy particles were imbedded in the limestone. The limestone usually is of a whitish color.

Oolitic grains, indicating the presence of the Fredonia

limestone, were brought up from depths of 200, 230, 240, 260, and 280 feet below the top of the well.

The St. Louis limestone is fine-grained, and usually is of a distinctly grayish color. Samples were brought up from depths of 300, 350, 370, 380, 395, 420, 435, 450, 460, 475, 482, 500, 510, 515, 530, 535, 540, 555, 585, 600, 620, 630, 638, 644, 650, 656, 662, 668, 680, 686, 692, and 712 feet below the top of the well.

At 735 feet below the top, a rather coarse-grained limestone was struck. At 755 feet, a medium-grained dark gray rock. At 780, a fine-grained dark gray rock. At 786, this dark gray rock was medium-grained in part. At 786, 807, 813, 840, and 860, more of this dark gray rock was struck. Most of this was fine-grained, although more medium-grained particles also occurred. This represents a thickness of 125 feet of rock, of which a part at least may belong to the Atherton horizon.

At 890, the coarse-grained limestones begin, and these are present also at depths of 900, 915, 960, 1000, 1030, and 1045 feet below the top. A minimum thickness of 155 feet of coarse-grained rock is present, which probably represents the Harrodsburg limestone horizon.

Medium-grained light gray rock occurs at depths of 1050, 1080, and 1100 feet. Fine-grained rock occurs at levels of 1124, 1127, and 1130, 1138, 1150, 1155, 1185, 1230 feet below the top of the well. This total thickness of 180 feet is regarded as representing the equivalents of the Knobstone formation. If this view be correct, the Knobstone has thinned out very much westward. The upper, medium-grained part may represent the Brooks bed, and the lower, fine-grained part includes the New Providence clay shale.

The typical Devonian Black Shale is represented by fragments from depths of 1234, 1253, 1315, and 1319 feet. At this depth, 85 feet below the top of the Black Shale, further drilling was abandoned.

An interpretation of these records suggests the following succession of strata, given in descending order.

Garfield sandstone, not exposed in the well.	
Clover-creek limestone, better exposed on the river bank....	**11 ft.**
Big Clifty sandstone, about	**18 ft.**

Ohara limestone, about ..... 107 ft.
Rosiclaire sandstone, may be represented by the sandy particles near the bottom of this limestone.
Fredonia limestone, oolitic, about ..... 145 ft.
St. Louis limestone, fine-grained, about ..... 455 ft.
Atherton bed may be represented in part by the darker rock ..... 105 ft.
Harrodsburg limestone ..... 155 ft.
Knobstone, including both the Brooks and the New Providence divisions ..... 185 ft.
Black Shale, penetrated to a depth of 85 ft. Total thickness unknown.

At Stephensport, at the mouth of Clover creek, the upper part of the limestone overlying the Big Clifty sandstone is exposed. A thickness of at least 11 feet is observed. The overlying strata are exposed along the roads going up the hill, both north and southeast of the town. In descending order, the following strata are exposed.

Tar Springs bed, consisting chiefly of sandstone.
Only the lower part is exposed. Southeast of the town the following subdivisions are noted:
Massive sandstone ..... 22 ft.
Chiefly clayey and shaly beds with a little limestone near the middle ..... 38 ft.
Stephensport bed; chiefly two limestone horizons separated by an intermediate clay horizon, which near the middle may be replaced by shaly or even by massive sandstone layers. Southeast of town, the following subdivisions are noted:
Upper limestone, containing large pentremites ..... 24 ft.
Clay ..... 16 ft.
Sandy layers ..... 14 ft.
Poorly exposed, probably chiefly shaly sandstone ..... 15 ft.
Lower limestone, oolitic toward the top ..... 26 ft.
Garfield bed, consisting chiefly of sandstone, but locally replaced to a considerable extent by clay. The total thickness of this bed is ..... 127 ft.
Southeast of town, the upper 44 feet of this bed consists of clay. Along the road north of town, this upper part consists chiefly of shaly sandstone layers, underlaid by clay, and this in turn by sandstone. Clay also occurs near the middle of the Garfield bed, and sandstone at the base, the intermediate part not being well exposed.

Clover-creek limestone is exposed at the mouth of Clover creek. The thickness may equal 15 feet, but the actual exposure is ..... 11 ft.
Big Clifty sandstone, not exposed, but struck in the well.

The Big Clifty sandstone is not exposed here. Where typically exposed, this sandstone is one of the most important in the series of rocks belonging to the lower part of the Carboniferous system. Judging from the well at Stephensport, the Big Clifty is reduced to a very small thickness at Stephensport. This is true certainly of the actual exposures in the vicinity of Sample, four miles east of Stephensport.

These sections at Stephensport, both the one actually exposed, and the one traversed by the well, will serve to indicate the relative position of the strata discussed in connection with the oil and gas wells of Meade and Breckenridge. A much greater accumulation of facts is at hand, and will form the subject of a more extended report.

PRELIMINARY REPORT ON OIL AND GAS POSSIBILITIES IN THE NEWBERG, CALHOUN, CENTRAL CITY AND MADISONVILLE QUADRANGLES, INCLUDING A DISCUSSION OF THE PRIMARY FACTORS GOVERNING SUCH ACCUMULATIONS

By F. M. Hutchinson.

Primary Factors necessary for an accumulation of Oil and Gas.—Practical work in many oil fields has demonstrated that four primary factors are instrumental in forming a valuable accumulation of oil and gas. These are: (1) A porous rock. (2) An impervious cover. (3) Water. (4) Favorable geologic structure.

1. *Porous Rock.* By a porous rock is meant one in which the pores are of sufficient size to permit of the passage of oil downward, or upward, or laterally as the case may be. Such a rock is usually a sandstone, but may be a limestone, shale or

any sedimentary rock. The need of a porous stratum is obvious, for in the minutely diffused state in which oil was originally formed it was wholly valueless, and consequently there must be some avenue of escape from its original resting-place to some point of concentration. Doubtless there are no absolutely non-porous rocks in nature, but there are many so dense as not to fall within the pale of the above definition. Further, there are no perfectly homogeneous rocks in nature, and many relatively non-porous areas occur in an otherwise porous stratum. These impervious areas afford more or less impassable barriers to the passage of oil, and constitute, for that particular place, the highest or lowest point in the porous rock. It is obvious that the amount of oil any rock can contain varies with its thickness and porosity.

2. *The Impervious Cover.* Over all oil-rocks in which valuable accumulations have been found is a relatively impervious stratum, through which the oil and gas will not pass even when subjected to an enormous pressure. This impervious stratum serves as a cover to retain these fluids in the underlying geologic reservoirs, and usually consists of a dense limestone or shale. Its need is obvious for without it the oil and gas would rise to the surface and be wasted.

3. *Water.* All oil-bearing rocks at the time of deposition were wholly saturated with water, of which by far the greater part was salt-water, this condition being due to the fact that sea-water, in which the rocks were deposited, is a strong brine. This briny condition, however, has probably had nothing whatever to do with the accumulations of oil and gas, water alone being the requisite.

Most oil-bearing rocks, however, are now partially dry, having in some mysterious way lost a portion of the inclosed water, but it is probable that most oil and gas pools were largely formed under conditions of complete saturation. This is a debatable point, but in any event the action of the water as an aid in forming the accumulations has very likely been the same.

Just what this action has been is a subject upon which all geologists do not agree, but the balance of evidence seems to indicate that the water has acted both as a heavier-than-oil

fluid, and as an agency of collection. Assuming this statement to be a fact, it is an easy matter to imagine the progress of a tiny globule of oil from the time it first became free to move in the oil bearing stratum, until it reached its final destination. At first it rose, say, from the bottom of the rock until stopped in its upward course by the impervious cover at the top, this action being due wholly to the fact that its specific gravity was less than that of the enveloping water. Arriving at the top of the rock it would indefinitely remain unless acted upon by some force other than gravity, since it is hardly probable that the globules of oil gathered together in this way could more than fill the irregularities in the roof of the rock. The water, however, is in motion, or sooner or later is set in motion, due probably to the crumpling of the earth's crust, but possibly to unequal heating, or the escape of water in one place, or its entrance at another, but, whatever the cause, it is sufficient that the water became in motion. Being in motion it would obviously collect the various globules of oil along its course, and carry them forward until arrested by some geologic reservoir, the highest within reach. Here, though the two substances had become mixed in transit, the heavier weight of the water would cause it to descend to the bottom, and the oil would be forced to the top.

4. *Favorable Geologic Structure.* By favorable geologic structure is meant such structure of the rocks as will tend to act as a reservoir, and retain the products of large areas within relatively small limits. A complete discussion of the various forms of structure as they affect the concentration of oil and gas may be found in the works of Orton, White, Griswold, and others, and will be included in the full report on the above named quadrangles now in course of preparation. For the purposes of this paper it is thought sufficient to give the principal places of accumulation, of oil and gas, which are as follows:* (1) In dry rocks the principal points of accumulation of oil will be at or near the bottom of the synclines, or

* NOTE—The paragraphs in regard to "principal places of accumulation," except for a modification of the last two paragraphs, was taken literally from Bul. 318, U. S. Geol. Sur., pp. 13, by W. T. Griswold.

at the lowest point of the porous medium, or at any point where the slope of the rock is not sufficient to overcome the friction, such as structural terraces or benches. (2) In porous rocks completely saturated the accumulations of both oil and gas will be in the anticlines, or along the level portions of the structure. Where the area of porous rocks is limited the accumulations will occur at the highest point of the porous medium, and where areas of impervious rocks exist in a generally porous stratum the accumulation will take place below such impervious stop, which is really the top limit of the porous rock. (3) In porous rocks that are only partly filled with water the oil accumulates at the upper limit of the saturated area. This limit of saturation traces a level line around the sides of each structural basin, but the height of this line may vary greatly in adjacent basins and in different sands of the same basin.

Partial saturation is the condition most generally found, in which case accumulations of oil may occur anywhere with reference to the geologic structure; it is most likely, however, to occur upon terraces or levels, as these places are favorable to accumulation in both dry and saturated rocks. Under all conditions the most probable locations for the accumulations of gas, which is the lightest of the three fluids, are on or near the crests of anticlines, though small folds, which are really small anticlines, along the sides of a syncline may hold a small supply of gas. The rocks may be so dense, however, that the gas can not travel to the anticline, but will remain in volume close to the oil. If any medium lighter in specific gravity than oil, but heavier than gas, as, for example, water vapor, exists in the rocks, the gas will rise above this medium, and be separated by it from the oil.

The statements given above are based on the assumption that the rocks have not been disturbed by faulting. The effect of faults on possible accumulations contained in the Newberg, Calhoun, Central City, and Madisonville Quadrangles, is hereinafter noted.

Sands.

The St. Louis limestone underlies these quadrangles at an

estimated depth of about 1,600 feet below No. 9 coal, and wells drilling below this depth would probably encounter only a succession of limestones. Oil may exist in these limestones, but it is probable that drilling through them now, in absolutely untested territory, would be a mere waste of money. The Trenton limestone, which is the best known oil-bearing limestone, lies at a depth of from 4,000 to 5,000 feet, in Western Kentucky, and is of course entirely too deep for profitable drilling.

Above the St. Louis limestone, however, are four or five sands, ranging in thickness from 10 feet to 60 feet, and any one or all of them, may contain accumulations of oil and gas.

Deep Wells.

No oil or gas pools have been found in these quadrangles, and only a very few test wells have been drilled. A well was drilled to a depth of 1,200 feet at Newman, in the Newberg Quadrangle, but no oil or gas was reported as being found. This well started in Ohio river alluvium, below the horizon of No. 9 coal, and encountered only a succession of sandstones, clays and shales. Four wells have been sunk to reported depths of six or seven hundred feet along the crest of the Rough Creek Anticline, three being situated 2 miles north of Calhoun, and one at Beech Grove, and in each of these wells a small quantity of oil and gas was found. As is hereinafter explained, however, only limited quantities of either of these fluids could have been expected within this badly disturbed area. No records of these wells have been obtained so far, and it is possible that none exist. Some four or five deep wells were drilled about one mile north of Central City, and a little oil and gas was found. But little information could be secured about the records of these wells, though two or three were reported as having been drilled to a depth of 1,400 feet. These wells start between coals No. 13 and No. 14. The Dun Oil Co. drilled a well 1,200 feet deep on the Elvis Bell farm 3 miles northwest of Sacramento, but no oil or gas was reported. It has not been possible to secure a record of this well. It starts near the horizon of No. 14 coal.

It is needless to say that these wells constitute practically no test whatever for these great areas, and for all oil and gas purposes these quadrangles may still be regarded as virgin territory.

Faults and Their Effects on Oil and Gas Accumulations.

Small quantities of oil and gas have been found in various places within the disturbed areas known as the Rough Creek Uplift. Two miles north of Calhoun is a spring from which a small quantity of oil has been issuing from a time which antedates the memory of the community's oldest inhabitants. A number of bore holes near this spring have also struck a like quantity of oil. At Beech Grove is a well 180 feet deep from which a gallon or so of oil is obtained daily, and a deep well, near the same town, obtained about the same amount. Most of the above mentioned wells also furnished a small supply of gas.

Now the question that confronts the practical oil man is this: Are these small flows of oil and gas indications of a larger supply near at hand of which only the outer edge, so to speak, has been penetrated?

It may be said in the beginning that the possibility of finding a rich pool of either oil or gas within the region affected by this fault is small indeed. It is quite possible that these "shows" of oil and gas are indications of former great pools in these vicinities, but the violent cataclysm which wrought the upheaval of this great anticlinal opened huge fissures, perhaps miles in length, along its top; and if oil will escape from a 10-inch hole at a rate of thousands of barrels per day, and gas at a rate running up into millions of cubic feet, how much more readily would it not issue from these enormous natural vents? Obviously, however large the former supply may have been it has long since been wasted, and the little that is found now is probably but a seepage of the small supply that lurked behind.

What is true of the Rough Creek Fault, is also true of the Curdsville Fault, and of the Fault south of Livermore, though in the latter cases a much smaller area is disturbed. It would

be well in drilling, however, to keep a mile or so away from these faults.

Favorable Oil and Gas Territory.

Of the four factors governing the accumulation of oil and gas, only structure can be determined in advance of the drill. Since adequate drilling to decide the nature and extent of the three remaining factors in the Newberg, Calhoun, Madisonville, and Central City Quadrangles has not been done, the possibilities of oil and gas in these quadrangles will be treated simply as regards the structural conditions presented.

The Moorman Syncline affords the best large territory for possible oil accumulations. Into this great basin, unless impeded by saltwater, the oil would flow from wide areas extending several miles to the North, to the South and to the East. Anywhere along its bottom from the point where it enters the eastern edge of the Central City Sheet, near Ceralvo, until it leaves the Madisonville Sheet, between Hanson and the city of Madisonville, may be considered as favorable territory. To secure a thorough test of all the sands the wells here should be drilled not less than 1,600 feet below No. 9 coal.

The small quantities of oil secured along the top of the Rough Creek Anticline indicate the probable former presence of a large supply within this region. Doubtless more or less of this oil was wasted when the faulting occurred, but it is probable that some of it flowed "down hill," so to speak, along the dip of the rocks to the North and to the South of the disturbed area, and may exist in quantity not far from its border lines. Anywhere within a mile or so of the southern and northern border lines may be regarded as likely territory. Near Jolly P. O. is a small syncline which could serve as an excellent reservoir for this soil, and this syncline is considered the best location on any of the quadrangles for a test well. The Newberg Quadrangle is generally flat and presents no very favorable structural conditions for either oil or gas.

Unfortunately, there are no areas in these quadrangles which can truly be called favorable gas territory from a structural standpoint. The small anticline lying to the southeast

of Earles, along the southern border of the Central City and Madisonville Quadrangles, may hold a good supply of gas. Elsewhere the most favorable structural areas are in the vicinities of Centretown, and Cleaton, and in the southeastern corner of the Central City Quadrangle, and about 2 miles southeast of West Louisville in the Calhoun Quadrangle.

OIL AND GAS FIELDS OF EASTERN AND SOUTH CENTRAL KENTUCKY

By M. J. Munn.

Prof. C. J. Norwood,
Director, Kentucky Geological Survey,
Lexington, Ky.

Dear Sir:

I have the honor to submit below a brief statement of the work done and the funds expended to date in the examination of the oil and gas fields of Eastern Kentucky.

This work was undertaken, in connection with that for a summary report on the oil and gas fields of the Appalachian region, by the United States Geological Survey. The Kentucky Geological Survey allotted the sum of $300 to be met by an equal amount from the U. S. Geological Survey for the purpose of affording a more detailed study of certain of these pools than could otherwise have been done. The special object of this work was to determine the relationship of these pools to the anticlines and synclines of the oil bearing beds, and to see if a knowledge of the structure thus obtained can be made of value to the producer in his work of developing these natural resources.

Work done in recent years by the United States Geological Survey in the oil fields of Pennsylvania, Ohio and West Virginia, has demonstrated the fact that many large pools of oil in those States show a very marked tendency to group themselves along the crests or sides of anticlines in such a manner

that when once the "habit" of accumulation of oil and gas in a given sand is determined in one locality the position of other still undiscovered pools in that sand can be closely estimated when the dip of the rocks is carefully mapped. By this work of the U. S. Geological Survey, pools in other oil sands were found to show no evidence of structural arrangement, and thus, geologic work can prove of little value in locating undiscovered pools in those sands. It is therefore of great importance to producers to know into which of these classes the oil pools of Kentucky fall, since that region seems destined in the future to receive increased attention from them, in their search for new pools. For this purpose I have selected certain tpyical fields in Eastern Kentucky, and have collected data with which the anticlines and synclines of the oil bearing beds may be carefully mapped. Spirit level lines were run to a large number of wells in and around these producing areas. With these levels the elevation above sea level of the mouths of wells were secured. Records giving the measured depth to the top of the oil or gas bearing bed were obtained from the owners, and the position of each well plotted on a map. With this material the exact shape of the oil bearing sand can be computed and represented on the map. The elevations above sea level of certain outcropping beds have also been secured and plotted with which it will be possible to determine approximately the degree of convergence existing between it and the oil sands and thus secure a reasonable basis for calculating the dip of the oil sands from a study of the surface rocks in areas where no wells have been drilled.

The areas thus studied in detail are the Campton oil field of Wolfe county, in which the Clinton sand is oil bearing, and the Steubenville, Johnson's Fork, Bachelor Hollow, Oil Valley, and Cooper pools of Wayne county where the Beaver creek and shallow sands are productive. In addition to this somewhat detailed study, a briefer examination has been made of the Ragland field, of Bath county, the Menefee county gas fields, the Irvine oil field of Estill county, and the Parmleyville, Mt. Pisgah, Slickford, Sunnybrook and Parnell pools of Wayne county, maps of most of which will be published.

I have had as levelman and general field assistant Mr. M.

W. Crouch, Topographic Draftsman, and have also employed two rodmen from time to time as the work demanded.

The field work done for this report during the months of October and November involved an expenditure of about $438, three hundred dollars of which is charged to the co-operative fund referred to above. The remainder was paid by the U. S. Geological Survey from the funds for a summary bulletin of the oil fields of the entire State.

The results of the work cannot at present be definitely determined since a suitable base map must yet be drawn in the office from material collected in the field, and the oil data plotted thereon, before the exact structural position of the pools can be determined. I estimate that between two and three months will be required in the office for one man to prepare the maps and text for this report. A bulletin containing this material will be submitted for publication as soon as the data can be prepared.

Very respectfully,
M. J. MUNN,
Geologist.

U. S. Geological Survey,
Washington, D. C., December 13, 1909.

THE BARYTES AND ASSOCIATED DEPOSITS OF CENTRAL KENTUCKY

BY F. JULIUS FOHS.

The following covers briefly the results of the investigation of these deposits to date:

Barytes occurs in Central Kentucky in three forms of deposits: Veins, Bed-veins, and Geodes. Of these only veins are of economic importance; occasionally a bed-vein might prove so.

1. *Veins.* By these are meant vertical or slightly inclined tabular deposits, which pinch and swell on following the dip

or strike. These may reach a maximum depth of 1,200 feet or more, a maximum in length of 4 miles or more, and a width of 12 feet or more, in Central Kentucky. As much of the strata may be eroded, the average known depth of a majority of the deposits is 600 feet, and how much deeper is not known, at least half of which carries a commercial product. The average which varies from 2 to 4 feet. These veins fill three types of fissures: Simple fissures; shift faults (displacement of walls lengthwise of vein and characterized by horizontal slickensiding and vertical walls); and normal faults (vertical displacement and irregular dip of walls). Simple fissures occur only occasionally. Shift faults are the common type in Central Kentucky and roughly parallel the axis of the Cincinnati Anticline. Normal faults carry deposits of good quality but not as frequently as shift faults in Central Kentucky. Zones of roughly parallel faults of either type occur one-half to one mile or more wide.

Barytes occurs in Kentucky alone or associated with fluorspar and calcite; to a minor extent, zinc blende and galena are found with these minerals. Barytes ranges through the entire known stratigraphic series of the State from the base of the Campnelson limestone of the Ordovician to well up into the Coal Measures. It is lacking in some of the beds, but this is due to selective deposition rather than to the lack of barium-bearing solutions penetrating such beds. Limestone is preferably the home of barytes and the associated minerals; quartzite or chert breccias are occasionally so; the least favorable of all are the shale beds. It is because of the preponderance of shale in the Cincinnatian series that it carries so little barytes; where suitable limestone beds occur in it, the barytes occurs also. In Central Kentucky, the richest deposits occur in the Lexington limestone and the next in value are those in the Winchester and the High Bridge limestones.

Fluorspar, in Central Kentucky, is not confined to the High Bridge limestones, but may be associated with the barytes at any horizon; however, it appears largely restricted to local areas—the Boone's Creek region, involving parts of Fayette and Clark counties, and the Mundy's Landing region, involv-

ing parts of Mercer and Woodford counties. It is in the latter area that calcite finds its maximum development.

Lead and zinc, chiefly as sulphides, are to be had as by-products in barytes mining, often in sufficient quantity to add materially to the profits, but the lack of proper milling facilities has prevented much being realized from this source. An occasional deposit may be expected in which the percentage of these metallic minerals may be sufficient to mine as a primary source of profit, though such instances are likely to be rare.

Barytes is the predominant mineral in Central Kentucky, with calcite next and then fluorspar; while zinc blende and galena make up the remaining smaller percentage of the deposits.

The origin of the deposits is a mooted question of which little of definite value has been learned. This much, however, having a practical bearing, has been determined: That the bulk of the barytes was deposited prior to the deposition of fluorspar and calcite and that there was a minor deposition of barytes after the fluorspar and calcite were deposited. This gave the barytes freeest play in deposition and left lesser spaces for the deposition of fluorspar and calcite. Where several or all of these minerals were present in a solution, precipitation took place in the order of their solubility beginning with the least soluble; barytes, fluorspar, galena, zinc blende and calcite. As a necessary corallary, barytes required the least amount of a precipitation force, and calcite the greatest. Hence it is that we find the barytes filling open cavities wherever they were to be found, fluorspar or fluorspar and calcite filling any remaining or later formed cavities, whereas galena, zinc blende and calcite are usually found in the less open parts of the veins (where they pinch, are filled with breccia or a horse, or have narrowed to a seam necessitating the spreading of the solutions into the wall rock thereby replacing the latter), where the circulation is necessarily restricted and where the greatest precipitating force was active, such as stagnation or impounding of solutions.

It will not be out of place to state here the results of a recent comparative study of the country rocks found inclosing

the best fluorspar shoots of the mines of the Kentucky-Illinois district. These facts taken in connection with what has previously been said regarding the likely relations of barytes and the associated minerals in the veins will no doubt be suggestive of what may be anticipated where a certain set of conditions is had, in the veins of either Western or Central Kentucky. The study in question showed that good fluorspar shoots are found in fifteen different combinations of geological formation-members. The shoots were directly the result of a combination of several or all of the following features of the wall rocks. Nos. 1, 2, and 3 are usually found in one wall, 4 and 5 in the opposite wall, while 6 affects both walls:

1. Open texture.
   a. porosity, b. lamination, c. shearage, d. brecciation.
2. Ready solubility.
   a. absence of clay. b. easy removal of impurities.
3. Ready interchange of elements of wall rock for those of solution (replacement).
4. Impermeable barrier.
   a. shale. b. clay gouge, c. compact limestone.
5. Presence of hydrocarbons.
6. Extent of displacement.
   a. different wall rocks. b. juxtaposed concavities.

Of these, the first three conditions are most necessary for replacement deposits, the last three for open fissure fillings.

2. *Bed-veins.* These usually result from the cementing brecciated limestones which have shrunk upon dolomitization or partial leaching. These are represented by the zinc deposits in the Devonic-Siluric limestones of Lewis county, also to be seen in Nelson and Oldham counties; by a bed of the St. Louis-Keokuk limestone brecciated and cemented with barytes in Estill and Menefee counties; and by a bed of Richmond limestone brecciated and cemented with zinc blende, gypsum, barytes and calcite in Lincoln county.

3. *Geodes.* Geodes bearing the minerals under consideration have been found notably in the Winchester limestone, in some of the Upper Cincinnatian limestones, in the Keokuk limestone and in the Waverly sandstones.

The only veins found thus far cutting Devonian slates in

Kentucky consist of narrow seams of quartz, or of pyrite, or of pyrite in a siliceous breccia. In southwestern Marion county are found faults in connection with small anticlinal and synclinal folds in the Keokuk limestone; in one case the breccia was cemented with gypsum and pyrite, and in nearby joints traces of lead and zinc are said to have been found. These occurrences are not of commercial interest.

The result of investigation, by counties, after having spent from a day to a month or more in a county as it may have required, of the barytes and associated minerals of the State outside of the Western Kentucky lead, zinc, and spar district is as follows:

Counties carrying veins, many of which are worthy of development are the following, (investigations have been completed in those counties here marked by an asterisk, in the others the work is in varying stages of completion); these counties all form part of the Central Kentucky district.

County.	No. of Veins.	On Farms.	County	No. of Veins.	On Farms.
Anderson	5	6	*Jessamine	12	40
Bourbon	25	6	*Lincoln	10	10
*Boyle	20	32	Madison	1	2
Clark	4	8	*Mercer	8	26
*Cumberland	1	1	*Monroe	1	1
*Fayette	32	47	Owen	2	4
Franklin	4	4	*Russell	1	1
*Garrard	11	25	Scott	9	10
*Harrison	2	4	Woodford	15	21
Henry	7	7			

Total, 19 counties, 149 veins, 255 farms.

The total number of veins is less than the total of the numbers given for the several counties since some of the veins extend into adjoining counties.

Some of the Lewis county zinc deposits may prove workable. The lead veins reported from eastern Estill county are not likely to prove of value, a question which it is hoped may be decided as soon as there may be opportunity to investigate them. Rockcastle county has some barytes deposits which from reports received are encouraging and will be investigated

as early as possible. In Casey county, the black barytes which has come to our notice requires investigation. Bracken, Montgomery, Nicholas, Robertson and possibly one or two other counties remain to be investigated.

The following counties have been investigated by the Survey, and either show none of the minerals under consideration or show them in such form and quantity as not to be worthy of prospecting: Barren, Boone, Breckenridge, Carroll, Clinton, Estill (western portion), Gallatin, Grayson, Grant, Marion, Meade, Menefee, Metcalfe, Nelson, Oldham, Pendleton, Shelby and Trimble.

RESOURCES OF LEWIS AND ROWAN COUNTIES.

By F. Julius Fohs.

The greater part of July and August, 1909, was spent in field work in Lewis and Rowan counties. They constitute a rough, hilly country, lying between the good farm lands of Mason, Bath and Felming counties on the west, and the coal lands of Greenup, Carter and Elliott counties on the east. The resources of Rowan and Lewis counties comprise building stones, clays and marls, oil and gas, some zinc ore, and a prolific water supply.

Building stone is one of the chief assets of these counties. The Cuyahoga member of the Waverly formation has an aggregate of 10 to 15 feet of valuable layers of blue to gray freestone of 8 to 32 inches each, suitable for masonry of all kinds. The stone splits, dresses and saws beautifully. In Rowan county, three quarries and plants prepare this stone for market. No modern plants have been erected in Lewis county, and while much stone has been quarried for rough masonry and flagging, the industry has come to a standstill owing to the large use of concrete instead. In the vicinity of Quincy and Garrison there is much good stone near a railroad and a suitable plant could no doubt establish a paving industry. To the south, away from the railroad, the ridges carry much good stone.

The Mississippian limestone, which rests on the Waverly, is suitable for ballast and flux, and is quarried for these purposes in the counties adjoining. A brown marble suitable for interior decoration occurs near the base of this limestone. Just above this a lithographic stone occurs in western Rowan county, but it is flawed too much to be of value. The limestone beneath the Ohio Shale in Lewis county was once manufactured into hydraulic cement, but the plant was not a success. Large quantities of this stone exist suitably located for the building up of an industry, and cheap coal can be had from the adjoining counties. The stone is of good quality and capital together with proper management could no doubt make it a success.

The only workable coal is in Rowan, where it adjoins Elliott county.

Clays, shales and marls of good quality and in large quantity abound in these counties. One brick plant has been built in each county, manufacturing high grade firebrick and building brick. The fire clay used comes from the Conglomerate formation and forms a bed up to 6 feet or more thick. One of these plants is at Firebrick in northeastern Lewis county. The building brick there is made from residual silicious clay and a Waverly shale. The other plant is at Haldeman in eastern Rowan county. The mining of the fireclay in eastern Lewis county was quite an industry until railroads were opened in Carter county when the industry was transferred there. Large quantities of good fireclay occur in these counties still, awaiting development. In eastern Lewis county, three miles east of Concord, one-half mile south of the railroad, is a bed of good fireclay 14 feet thick at the top of the Silurian shales. Beneath this fireclay is more than 100 feet of shales suitable for building and common brick, tile, paints, etc. Some of the beds of the Ohio Shale might be used similarly. Marl beds suitable for fertilizers occur in the Upper Cincinnatian in eastern Lewis county. A red ochre occurs locally in the Conglomerate formation which was quarried for paint at one time.

Much prospecting for oil and gas has been done, covering the greater part of both counties. The only wells being pumped, however, are those of the Alfrey farm, 35 in number,

pumping from the Ragland sand at an average depth of 330 feet, in southwestern Rowan county. In notheastern Rowan county is a gas well which has been burning for seven years. On Straight fork, in Lewis county, some wells at a depth of 100 feet showed minute quantities of petroleum. The Ohio and Sunbury carbonaceous shales are reserves for future distillation of petroleum.

Salt wells were once operative in Salt Lick valley in Lewis county, but are now of only historical interest. Both counties, especially Lewis, are favored with an abundance of good spring waters. Magnesia waters issue in copious springs from the base of the Devonian limestone; the Silurian limestone also yields magnesian waters. Chalybeate and sulphur waters issue from the Ohio shales. Two health resorts are established on the basis of these excellent magnesia, chalybeate and sulphur waters at Esculapia and Glenn Springs in Lewis county. Freestone waters issue from the Waverly formation. Excellent fresh water issues from the Mississippian limestones. In addition, the Ohio river borders Lewis county, the Licking river borders Rowan county and both counties have innumerable creeks.

Zinc occurs in Lewis county in the Devonian limestone. It cements brecciated magnesia limestone. A great number of outcrops were examined but only looked promising enough to suggest future development; this is known as the Capt. Kinney prospect, 4 miles southwest of Vanceburg.

There is an abundant supply of road materials. The roads with a few exceptions are among the worst in the State, largely following creek beds. Nothing could add more to the upbuilding of these counties than the building of good roads. The Cincinnatian limestone of northern and eastern Lewis county, the Mississippian limestones, the hard iron-seamed sandstones (thrown away at the quarries now) of the Waverly formation, and the gravels of the stream beds, yield suitable available materials in all parts of the two counties.

Pyrite and sulphur occur in the Devonian shales, but are not of value. A good bed of molding sand occurs at Sand branch, three miles up the river from Vanceburg.

ANALYSES AND HEAT VALUES OF COALS

By R. D. Quickel.

Prof. Charles J. Norwood, Director,
State Geological Survey.

Sir:

I have the honor to submit herewith a report on the analyses and determinations of heat values (b. t. u's.) made of a number of samples of coal collected by the Survey together with samples sent to the Survey for testing, from time to time. The analyses (compiled from the Survey records) were in the main made by Dr. Alfred M. Peter and Mr. J. S. McHargue, chemists of the Survey. The b. t. u. determinations were made by Mr. George F. Brockman and myself. B. t. u. determinations were made by the Parr calorimeter and by the Emerson bomb calorimeter.

Respectfully,
Ralph D. Quickel.

Analyses Arranged by Counties.

Bell County.

No. 2748. Coal, from mine No. 2, Straight Creek Coal Co., Bell Co., Ky., collected by J. S. Cheyney, 1907, composite of three samples of the Pineville seam.

No. 2749. Coal, from Big Hill Coal Co's. mine, Bell Co., Ky., collected by J. S. Cheyney, 1907. Pineville Seam. Thickness of bed 43 inches coal.

No. 2759. Coal, from Straight Creek Coal Co's. property, Bell C.o, Ky., collected by J. S. Cheyney, 1907, from vein about 200 feet above the Pineville Seam.

No. 2791. Coal, from the Wallsend Coal Co's. Mine No. 1, Bell Co., Ky., collected by A. G. Spillman, December 9, 1906, from No. 1 Pineville Seam.

No. 2792. Coal, from the Wallsend Coal Co's. Mine No.

3, Bell Co., Ky., collected by A. G. Spillman. Composite of two samples from the Pineville Seam.

No. 2793. Coal, from Straight Creek Coal Co's. Mine No. 2, Bell Co., Ky., collected by A. G. Spillman, December 4, 1904. Composite of two samples from the Pineville Seam.

No. 2887. Coal, from Winona Coal & Coke Co's. mine at Gravity, Bell Co., Ky., collected by the Company August 8, 1908, from the Bennets Fork Seam of coal in the Middlesboro District.

No. 2888. Same as No. 2887.

No. 2916. Cannel Coal from the Poplar Lick vein on Hignite Creek. Collected by J. W. Gunn, 1908, on the land belonging to the Middlesboro Land Owning and Leasing Co.

COMPOSITION OF THESE BELL COUNTY COALS, AIR DRIED.

Number	2748	2749	2750	2791	2792
Moisture	2.30	2.47	2.26	1.15	1.13
Volatile combustible matter	37.69	39.03	39.68	36.80	35.54
Fixed carbon	56.85	57.16	51.64	60.02	61.22
Ash	3.16	1.34	6.42	2.03	2.11
Total	100.00	100.00	100.00	100.00	100.00
Phosphorus	0.031	0.013	0.009	0.000	0.000
Sulphur	0.89	0.77	3.22	0.65	0.71
Coke	60.01	58.50	58.06	62.05	63.33
Specific gravity	1.265	1.256	1.32	1.27	1.30
Color of ash	Light Brown	Light Brown	Lilac	Reddish Brown	Reddish Brown
Character of coke	Spongy	Spongy	Spongy	Dense	Dense
B. T. U. per lb	*14,641	*14,952	*14,173	*14,329	*14,173

*By Parr Calorimeter.

Number	2793	2887	2838	2916
Moisture	1.45	1.29	1.27	1.20
Volatile combustible matter	35.50	39.03	37.93	38.75
Fixed carbon	60.74	54.97	56.27	34.43
Ash	2.31	4.71	4.53	25.62
Total	100.00	100.00	100.00	100.00
Phosphorus	0.000	0.003	0.003	0.000
Sulphur	0.91	1.20	1.25	0.54
Coke	63.05	.....	.....	.....
Specific gravity	1.26	1.267	1.247	1.362

	Reddish			Brownish
Color of ash	Brown	Gray	Gray	Gray
Character of coke	Spongy	Spongy	Spongy	Dense
B. T. U. per lb	*14,141	*13,851	*13,726	*10,695

* By Parr Calorimeter.

Boyd County Coal.

No. 3026. Coal, from the Princess Mine, Big Run Coal Co., Princess, Boyd Co., Ky. Sample sent by the Company.

COMPOSITION OF THIS BOYD COUNTY COAL, AIR DRIED.

Number	3026
Moisture	3.30
Volatile combustible matter	34.80
Fixed carbon	53.22
Ash	8.68
Total	100.00
Phosphorus	0.00
Sulphur	2.10
Specific gravity	1.317
B. T. U. per lb.	*12,234

* By Parr Calorimeter.

Crittenden County Coal.

No. 3042. Coal, two miles from Blackford, Crittenden Co., Ky. Collected by John C. Worsham and designated as No. 1. Bed 36 inches.

No. 3043. Same as No. 3042 but designated as No. 2.

COMPOSITION OF THESE CRITTENDEN COUNTY COALS, AIR DRIED.

Number	3042	3043
Moisture	2.07	2.23
Volatile combustible matter	31.65	31.87
Fixed carbon	60.58	60.78
Ash	5.70	5.12
Total	100.00	100.00

Sulphur	1.41	1.37
Coke	54.88	55.66
Specific gravity	1.268	1.33
Color of ash	Brown	Brown
Character of coke	Porous	Porous
B. T. U. per lb.	*13,665	*13,140

* By Bomb Calorimeter.

Daviess County Coal.

No. 2870. Coal, from Owensboro Coal and Land Co's. mine, three miles west of Owensboro in Bon Harbor Hills, Daviess Co., Ky. Collected by F. J. Fohs, June 3, 1908. Thickness of bed 49 inches.

COMPOSITION OF THIS DAVIESS COUNTY COAL.

Number	2870
Moisture	7.89
Volatile combustible matter	33.72
Fixed carbon	44.68
Ash	13.71
Total	100.00

Phosphorus	0.00
Sulphur	4.02
Coke	58.39
Specific gravity	1.372
Color of ash	Lilac
Character of coke	.....
B. T. U. per lb.	*11,735

* By Parr Calorimeter.

Floyd County Coals.

No. 2893. Coal, from Preston Coal Co., Floyd Co., Ky. Collected by A. G. Spillman. No. 1 coal. Section is, coal 6 inches, slate 2 inches. Coal 35 inches, face of main entry.

No. 2894. Coal, from Preston Coal Co., Floyd Co., Ky. Collected by A. G. Spillman, from face of first right. No. 1 coal. Section is, coal 6 inches, slate 2 inches. Coal 37 inches.

COMPOSITION OF THESE FLOYD COUNTY COALS, AIR DRIED.

Number	2893	2894
Moisture	2.48	2.58
Volatile combustible matter	36.71	37.15
Fixed carbon	52.36	50.87
Ash	8.45	9.40
Total	100.00	100.00
Phosphorus	0.0047	0.0026
Sulphur	1.568	0.92
Specific gravity	1.3234	1.3023
Color of ash	Lilac	Lilac
Character of coke	firm and porous	firm and porous
B. T. U. per lb.	*13,090	*12,870

* By Parr Calorimeter.

Harlan County Coal.

No. 2696. Coal, from mouth of Straight Creek, Poor Fork. Collected by J. M. Hodge, 1906.

COMPOSITION OF THIS HARLAN COUNTY COAL, AIR DRIED.

Number	2696
Moisture	5.92
Volatile combustible matter	32.95
Fixed carbon	56.66
Ash	4.47
Total	100.00
Phosphorus	0.004
Sulphur	0.68
Coke	61.13
Specific gravity	1.378
Color of ash	Reddish yellow
Character of coke	Friable
B. T. U. per lb.	*12,490

* By Parr Calorimeter.

Henderson County Coals.

No. 2869. Coal, from Pittsburg Coal Co's. mine, Baskett,

Henderson Co., Ky. Collected by F. J. Fohs, June 4, 1908. Sample is a composite of averages taken from Reeds room, right North entry and second room, first right South entry. Sulphur partly excluded from sample. All slate excluded. Henderson bed.

No. 2905. Coal, from Keystone mine, Henderson Co., Ky. Sample from main heading 550 feet from shaft. Coal 4 feet 9½ inches thick with three prominent sulphur partings, none 1 inch thick.

No. 3105. Coal, from Utopia mine, Utopia Coal Co., Henderson Co., Ky. Collected by F. J. Fohs, December 6, 1907. Thickness of bed 46 inches. Black slate roof, 46 inches coal with sulphur in irregular bands, fireclay floor.

No. 3106. Coal, from Zion Coal Co's. mine, Henderson Co., Ky. Collected by F. J. Fohs, December 4, 1907. Seam has one very thin sulphur band and is harder at the top than at the bottom.

No. 3107. Coal, from Bluff City mine, John Archbold Coal Co., Henderson Co., Ky. Collected by F. J. Fohs, December 5, 1907. Thickness of bed 48 inches.

No. 3108. Coal, from Basket mine, Pittsburg Coal Co., Baskett, Henderson Co., Ky. Collected by F. J. Fohs, from main South heading. Thickness of bed, 44 inches.

No. 3109. Coal, from Spottsville mine, Green River Coal Co., Spottsville, Henderson Co., Ky. Collected by F. J. Fohs, December 3, 1907. Thickness of bed, 44 inches.

No. 3110. Coal, Smith Mills Coal & Mining Co's. mine, Henderson Co., Ky. Collected by F. J. Fohs, December 5, 1907. Depth to top of coal, 173 feet. Thickness of bed, 82 inches.

COMPOSITION OF THESE HENDERSON COUNTY COALS, AIR DRIED.

Number	2869	2905	3105	3106
Moisture	7.57	3.08	6.23	6.05
Volatile combustible matter	34.95	35.72	34.67	37.23
Fixed carbon	46.06	45.05	46.93	46.02
Ash	11.42	16.15	12.17	10.70
Total	100.00	100.00	100.00	100.00

Phosphorus	0.00	0.00	trace	trace
Sulphur	2.54	7.76	2.58	3.24
Coke	51.48	.....	59.10	56.72
Specific gravity	1.346	1.315	1.34	1.356
Color of ash	lilac	grayish brown	gray	lilac
Character of coke	.....	.....	dense	dense
B. T. U. per lb.	*11,980	*11,540	†11,860	*11,510
Number	3107	3108	3109	3110
Moisture	5.72	5.83	5.75	7.58
Volatile combustible matter	35.23	35.71	38.10	32.24
Fixed carbon	42.60	48.14	46.95	49.21
Ash	16.45	10.32	9.20	10.97
Total	100.00	100.00	100.00	100.00
Phosphorus	trace	trace	trace	trace
Sulphur	6.34	3.11	2.73	2.16
Coke	59.05	58.46	56.15	60.18
Specific gravity	1.441	1.312	0.322	1.332
Color of ash	lilac	lilac	lilac	gray
Character of coke	dense	dense	dense	.....
B. T. U. per lb.	†10,600	†11,760	†12,220	*11,380

* By Parr Calorimeter.

† By Bomb Calorimeter.

Hopkins County Coals.

No. 2789. Coal, from Oak Hill mine, Hopkins Co., Ky. Collected by A. G. Spillman. Composite of averages from room No. 9, 1st South entry and room No. 14, 1st South entry. Thickness of bed, 60 inches and 32 inches.

No. 3103. Coal, from Crabtree Mine, Hopkins Co., Ky. Collected by A. G. Spillman. Composite of averages from room No. 38, off of 10th East entry. Thickness of bed, 60 inches.

No. 3104. Coal, from Crabtree mine, Hopkins Co., Ky. Collected by A. G. Spillman. Taken in cross-cut between 7th East and 8th East entries. Thickness of bed, 64 inches.

COMPOSITION OF THESE HOPKINS COUNTY COALS, AIR DRIED.

Number	2789	3103	3104
Moisture	1.74	4.45	5.29
Volatile combustible matter	39.97	37.93	37.06

Fixed carbon	50.13	49.77	48.42
Ash	8.16	7.85	9.23
Total	100.00	100.00	100.00
Phosphorus	0.00	0.00	0.00
Sulphur	2.84	2.89	3.57
Coke	58.29	57.62	57.65
Specific gravity	1.28	1.311	1.319
Color of ash	light purple	lilac	lilac
Character of coke	light spongy	dense	dense
B. T. U. per lb.	*11,821	†12,255	†12,620

* By Parr Calorimeter.
†By Bomb Calorimeter.

Johnson County Coals.

No. 2889. Coal, from White House mine, Johnson Co., Ky. Sample from Big Vein.

No. 2890-a. Coal, from White House mine, Johnson Co., Ky. Sample from Big Vein.

No. 2891-b. Coal, from White House mine, Johnson Co., Ky. Sample from Big Vein.

No. 2895. Coal, from Rittenhouse mine, Tibbals Coal Co., collected by A. G. Spillman from near face of First Right entry. No. 1 Seam Section is coal 26 inches. Bone coal 3 inches, coal 5 inches.

No. 2896. Coal, from Meek mine, Johnson Co., Ky., collected by A. G. Spillman from near face of First Left entry. Section is 26 inches coal.

No. 2897. Cannel coal, from Sandy River Coal Co., Johnson Co., Ky. Collected by A. G. Spillman, in Room No. 6, on Bucher entry. 19 inches cannel coal.

No. 2898. Coal, from Sandy River Coal Co., Johnson Co., Ky. Collected by A. G. Spillman, from Room No. 6, Bucher entry. Bituminous coal, 13 inches thick.

No. 2899. Coal, from Rittenhouse mine, Tibbals Coal Co., collected by A. G. Spillman from near mouth of Second Right entry. No. 1 coal. 38 inches thick.

No. 2900. Coal, from near Meek mine, Johnson Co., Ky.

Collected by A. G. Spillman, Second Right air course. Coal 33 inches.

No. 3096. Coal, from Muddy Branch mine, North East Coal Co., Johnson Co., Ky. Collected by A. G. Spillman, in last break through, between 3d and 4th right seam. 16 inches.

No. 3097. Coal, from Muddy Branch mine, North East Coal Co., Johnson Co., Ky. Collected by A. G. Spillman, from face of 1st Left entry. Seam 47 inches.

COMPOSITION OF THESE JOHNSON COUNTY COALS, AIR-DRIED.

Number	2889	2890-a	2891-b	2895	2896
Moisture	2.95	2.50	3.12	2.87	2.82
Volatile combustible matter	37.60	32.57	39.20	38.79	37.45
Fixed carbon	49.55	46.98	49.93	54.33	53.25
Ash	9.90	17.95	7.75	4.01	6.48
Total	100.00	100.00	100.00	100.00	100.00
Phosphorus	trace	trace	trace	trace	trace
Sulphur	0.83	0.74	0.96	0.71	0.95
Coke	.....	.....	.....	.....	.....
Specific gravity	1.312	1.389	1.299	1.285	1.2742
Color of ash	lilac	gray	yellow	brown	brown
Character of coke	spongy	dense	porous	firm & porous	firm & porous
B. T. U. per lb.	*12,635	*11,623	*13,016	*13,443	*13,234

Number	2897	2898	2899	2900	3096	3097
Moisture	1.52	2.17	2.52	2.40	3.06	3.40
Volatile comb. matter	46.08	32.75	36.90	37.43	37.44	36.53
Fixed carbon	42.47	50.23	51.96	54.80	55.21	57.43
Ash	9.93	14.85	8.62	5.37	4.29	2.60
Total	100.00	100.00	100.00	100.00	100.00	100.00
Phosphorus	trace	trace	trace	trace	0.00	0.00
Sulphur	0.79	0.82	0.683	0.66	2.11	0.80
Coke	.....	.....	.....	.....	59.50	60.07
Specific Gravity	1.2681	1.4041	1.3238	1.3024	1.303	1.227
Color of ash	brown	brown	brown	brown	lilac	brown
Character of coke	firm & porous	dense	firm & porous	firm & porous	dense	porous
B. T. U. per lb.	*12,990	*11,865	*12,840	*13,330	*12,655	*13,460

* By Parr Calorimeter.

Knott County Coals.

No. 2735. Coal, from mouth of Dan Fork, Buckhorn Creek, Pardee, Knott Co., Ky. Collected by J. M. Hodge, 1906. Thickness of bed, 74 inches.

No. 2755. Coal, from ½ mile above Henderson on Troublesome creek, Jasper Baker, Knott Co., Ky. Collected by J. M. Hodge, October, 1906. Thickness of bed, 47 inches.

No. 2756. Coal, from Carr Fork at mouth of Little Carr, Knott Co., Ky. Collected by J. M. Hodge, October, 1906. Thickness of bed, 46 inches.

COMPOSITION OF THESE KNOTT COUNTY COALS, AIR DRIED.

Number	2735	2755	2756
Moisture	1.76	1.44	2.92
Volatile combustible matter	41.98	41.67	34.90
Fixed carbon	49.67	52.24	54.36
Ash	6.59	4.65	7.82
Total	100.00	100.00	100.00
Phosphorus	0.013	0.009	0.009
Sulphur	1.83	1.05	0.65
Coke	56.26	56.89	62.18
Specific gravity	1.294	1.264	1.367
Color of ash	reddish yellow	reddish brown	salmon
Character of coke	dense spongy	spongy	friable
B. T. U. per lb.	*13,862	*14,329	*12,616

* By Parr Calorimeter.

Lawrence County Coals.

No. 2660 Coal, from Lick Creek entry on left side going up Lawrence county, Ky. Sample marked Dr. Watson's coal, collected by A. R. Crandall, April 27, 1905.

No. 2997. Coal, from Crystal Block Coal Co., Louisa, Lawrence Co., Ky.

COMPOSITION OF THESE LAWRENCE COUNTY COALS, AIR DRIED.

Number	2660	2997
Moisture	4.80	2.95

Volatile combustible matter	36.84	35.18
Fixed carbon	49.82	55.17
Ash	8.54	6.70
Total	100.00	100.00
Phosphorus	0.00	0.00
Sulphur	0.74	1.01
Coke	58.36	.....
Specific gravity	1.319	1.29
Color of ash	flesh	.....
Character of coke	spongy	.....
B. T. U. per lb.	*12,615	*12,997

* By Parr Calorimeter.

Lee County Coals.

No. 2703. Coal, from ⅜-mile up Stone Coal Branch, Sturgeon Creek, Lee Co., Ky. Collected by J. M. Hodge, 1906. Old opening.

No. 2704. Coal, from ¼-mile up Duck Fork, Sturgeon Creek, Lee Co., Ky. Collected by J. M. Hodge, 1906. Main coal.

No. 2819. Coal, from Sinking Creek, Lee Co., Ky. Collected by A. M. Miller, 1907. Coal No. 1 (1st coal above limestone). Thickness of bed 24 inches.

No. 2820. Coal, from Kentucky River Block Mine, White Ash Coal Co., Lee Co., Ky. Collected by A. M. Miller. Lee Formation. Thickness of bed, 37 inches.

No. 2821. Coal, from White Ash Coal Co. mine on Derrickson creek near mouth, Lee Co., Ky. Collected by A. M. Miller. Lee Formation. Coal No. 2. Thickness of bed, 40 inches.

COMPOSITION OF THESE LEE COUNTY COALS, AIR DRIED.

Number	2703	2704	2819	2820	2821
	Not air dried	Not air dried			
Moisture	4.16	3.53	2.72	2.05	1.90
Volatile combustible matter	38.97	40.51	39.67	40.42	41.20
Fixed carbon	49.24	49.00	48.28	50.98	51.09
Ash	7.63	6.96	9.33	6.55	5.81
Total	100.00	100.00	100.00	100.00	100.00

Phosphorus	0.022	0.004	0.00	0.00	0.00
Sulphur	1.97	2.60	4.78	2.86	2.36
Coke	56.87	55.96	57.61	57.53	56.90
Specific gravity	1.345	1.299	1.34	1.29	1.30
Color of ash	brown	purple	red	brown	brownish red
Character of coke	spongy	spongy	.....	.....	.....
B. T. U. per lb.	*13,958	*13,457	*12,540	*12,855	*13,125

*By Parr Calorimeter.

Letcher County Coals.

No. 2697. Coal, from Franks Branch, Oven Fork, Letcher Co., Ky. Collected by J. M. Hodge.

No. 2698. Coal, from Smith Branch, Oven Fork, Letcher Co., Ky. Collected by J. M. Hodge. Thickness of bed 66 inches.

No. 2736. Coal, from Line Fork, Joe Cornett, Letcher Co., Ky. Collected by J. M. Hodge, August, 1906.

No. 2753. Coal, from Right Fork, Millstone Creek, Melvin Tolliver, Letcher Co., Ky. Collected by J. M. Hodge, September, 1907. Thickness of bed, 71 inches.

No. 2754. Coal, from Millstone Branch, Rockhouse creek, John Lexton, Letcher Co., Ky. Collected by J. M. Hodge, September, 1906.

Composition of these Letcher County Coals, Air Dried.

Number	2697	2698	2736	2753	2754
Moisture	2.23	2.93	1.01	1.43	0.39
Volatile combustible matter	35.37	33.54	34.04	37.00	46.11
Fixed carbon	56.21	54.12	39.10	53.35	40.50
Ash	6.19	9.41	25.85	8.22	13.00
Total	100.00	100.00	100.00	100.00	100.00
Phosphorus	0.057	0.051	0.00	0.007	0.00
Sulphur	0.66	0.75	0.54	0.71	2.00
Coke	62.40	63.53	64.95	61.57	53.50
Specific gravity	1.313	1.354	1.493	1.333	1.309
Color of ash	buff	yellowish	reddish brown	buff	grayish brown
Character of coke	dense spongy	dense spongy	friable	spongy	dense
B. T. U. per lb.	*13,700	*13,080	*11,310	*13,895	*13,895

* By Parr Calorimeter.

Leslie County Coals.

No. 2737. Cannel coal, from Laurel Fork, Cutshin creek, A. Cornett, Leslie Co., Ky. Collected by J. M. Hodge, August, 1906. Section is 69 inches cannel coal, 6 inches coal.

No. 2738. Cannel coal, from Laurel Fork, Cutshin creek. A. Cornett, Leslie Co., Ky. Collected by J. M. Hodge, August, 1906. Section is Coal (?), cannel coal 69 inches.

COMPOSITION OF THESE LESLIE COUNTY COALS, AIR DRIED.

	2737	2738
Number		
Moisture	1.56	1.67
Volatile combustible matter	46.94	38.78
Fixed carbon	45.16	53.91
Ash	6.34	5.64
Total	100.00	100.00
Phosphorus	0.00	0.004
Sulphur	0.72	1.34
Coke	51.50	59.55
Specific gravity	1.225	1.290
Color of ash	buff	lt. brown
Character of coke	dense	dense spongy
B. T. U. per lb.	*14,140	*14,140

* By Parr Calorimeter.

Martin County Coals.

No. 2658. Coal, from head of Middle Fork, Rockcastle creek, near Copperas Gap, Martin Co., Ky. Collected by A. R. Crandall. Sample marked E coal. Thickness of bed 62 inches.

No. 2659. Coal, from Pigeon Roost Branch, Laurel Fork of Middle Fork, Rockcastle creek. Collected by A. R. Crandall. April 26, 1905. Sample marked E coal. Thickness of bed, 66 inches.

COMPOSITION OF THESE MARTIN COUNTY COALS, AIR DRIED.

	2658	2659
Number		
Moisture	3.15	3.05

Volatile combustible matter	38.64	36.83
Fixed carbon	51.25	46.57
Ash	6.96	13.55
Total	100.00	100.00
Phosphorus	0.00	0.00
Sulphur	0.82	0.69
Coke	68.21	60.12
Specific gravity	1.372	1.318
Color of ash	purplish	flesh
Character of coke	spongy	spongy
B. T. U. per lb	*12,175	*12,210

* By Parr Calorimeter.

McLean County Coals.

No. 2901. Coal, from Green River Coal & Coke Co., Island, McLean Co., Ky. Collected by A. G. Spillman, from face of Room No. 1 on 1st North Entry, East side of shaft. Thickness of bed, 46 inches.

No. 2902. Coal, from Green River Coal & Coke Co., Island, McLean Co., Ky. Collected by A. G. Spillman from face of Room No. 1 on 3d North Entry, East side of shaft. Thickness of bed, 46 inches.

No. 2903. Coal, from Alva Karnes mine, near Island, McLean Co., Ky. Collected by A. G. Spillman, from face of Main East Entry.

No. 2904. Coal, from Alva Karnes mine, near Island, McLean Co., Ky. Collected by A. G. Spillman, from face of Room No. 1 on 2d west Entry. Thickness of bed, 46 inches.

COMPOSITION OF THESE MCLEAN COUNTY COALS, AIR DRIED.

Number	2901	2902	2903	2904
Moisture	2.87	2.68	2.55	2.54
Volatile combustible matter	39.53	37.35	41.18	42.01
Fixed carbon	49.17	47.87	47.14	46.78
Ash	8.43	12.10	9.13	8.67
Total	100.00	100.00	100.00	100.00
Phosphorus	0.00	0.00	0.00	0.00
Sulphur	3.54	2.86	3.30	3.14

Coke	57.60	59.97	56.27	55.45
Specific gravity	1.283	1.344	1.275	1.293
Color of ash	gray	brown	brown	brownish gray
Character of coke	light	.....	.....	.....
B. T. U. per lb.	*12,156	*12,639	*11,970	*12,390

* By Parr Calorimeter.

Menefee County Coal.

No. 2825. Coal, from Red River Valley R. R. mine on Amet Fork of Indian creek, Menefee Co., Ky. Collected by A. M. Miller, 1907. Coal No. 1. Thickness of bed, 31 inches.

COMPOSITION OF THESE MENEFEE COUNTY COALS, AIR DRIED.

Number	2825
Moisture	2.95
Volatile combustible matter	43.28
Fixed carbon	47.93
Ash	5.84
Total	100.00
Phosphorus	0.00
Sulphur	1.52
Coke	53.77
Specific gravity	1.28
Color of ash	gray
Character of coke	.....
B. T. U. per lb.	*12,870

* By Parr Calorimeter.

Morgan County Coals.

No. 3062. Coal, from the North Fork Cannel Coal Co., Wrigley, Morgan Co., Ky. Sample sent by the company and designated as No. 1. Bed, 30 inches.

No. 3063. Coal, from the North Fork Cannel Coal Co., Wrigley, Morgan Co., Ky. Sample sent by the company and designated as No. 2. Bed, 30 inches.

No. 3064. Coal, from the North Fork Cannel Coal Co., Wrigley, Morgan Co., Ky. Sample sent by the company and designated as No. 3. Bed, 30 inches.

No. 3065. Coal, from the North Fork Cannel Coal Co., Wrigley, Morgan Co., Ky. Sample sent by the company and designated as No. 4. Bed, 30 inches.

No. 3066. Coal, from the North Fork Cannel Coal Co., Wrigley, Morgan Co., Ky. An average of samples Nos. 3062 and 3063.

No. 3067. Coal, from the North Fork Cannel Coal Co., Wrigley Morgan Co., Ky. An average of samples Nos. 3064 and 3065.

No. 3074. Cannel coal, from H. M. Collins mine on "May Oakley Branch" of North Fork of Licking river. Sample collected by North Fork Cannel Coal Co., May, 1909.

No. 3164. Coal, from Lee Coal Co's. mine No. 1 at Redwine, about 3 miles from Wrigley, Morgan Co., Ky. Sample collected by the company September, 1909. The company designated this sample as No. 1, representing 14 inches and is known as top coal. Bed, 42 inches.

No. 3165. Coal, from Lee Coal Co's. mine No. 1 at Redwine, about 3 miles from Wrigley, Morgan Co., Ky. Sample collected by the company September, 1909. The company designated this sample as No. 1, representing the bottom coal from top to bottom. Bed, 42 inches.

No. 3166. Coal, from Lee Coal Co's. mine, No. 1 at Redwine about 3 miles from Wrigley, Morgan Co., Ky. Sample collected by the company, September, 1909. The company designates this sample as No. 3, representing the entire bed from top to bottom.

COMPOSITION OF THESE MORGAN COUNTY COALS, AIR DRIED.

Number	3062	3063	3064	3065	3066
Moisture	1.33	1.03	1.30	1.10	1.18
Volatile combustible matter	52.72	42.12	53.25	44.48	47.32
Fixed carbon	32.66	27.85	33.50	30.62	29.41
Ash	13.29	29.00	11.95	23.80	22.22
Total	100.00	100.00	100.00	100.00	100.00
Phosphorus	0.00	0.00	0.00	0.00	0.00
Sulphur	1.57	2.74	1.68	1.28	2.71
Coke	29.37	.....	.....	.....	.....
Specific gravity	1.227	1.417	1.248	1.361	1.310
Color of ash	lilac	lilac	lilac	lilac	lilac

Character of coke	dense	dense	dense	dense	dense
B. T. U. per lb.	*12,530	*11,289	*13,060	*11,283	*11,285
Number	3067	3074	3164	3165	3166
Moisture	1.38	1.60	1.45	1.65	1.38
Volatile combustible matter	47.17	49.68	45.25	51.80	50.19
Fixed carbon	33.68	31.72	28.50	33.25	32.21
Ash	17.77	17.00	24.80	13.30	16.22
Total	100.00	100.00	100.00	100.00	100.00
Phosphorus	0.00	0.00	0.00	0.00	0.00
Sulphur	1.71	1.88	1.57	1.78	1.46
Coke	.....	.....	53.30	46.55	48.43
Specific gravity	1.314	1.294	1.406	1.283	1.308
Color of ash	lilac	brown	brown	brown	brown
Character of coke	dense	very friable	.....	porous	.....
B. T. U. per lb.	*11,940	*11,140	*12,045	*13,160	*12,605

* By Parr Calorimeter.

Muhlenberg County Coals.

No. 3070. Coal, from W. P. Robertson's shaft at Moorman, Muhlenberg Co., Ky. Collected by J. M. Thompson, May 3, 1909. Bed, 60 inches.

No. 3075. Coal, from Diamond Block Mines, near Drakesboro, Muhlenberg Co., Ky. Collected by J. M. Thompson, May, 1909.

COMPOSITION OF THESE MUHLENBERG COUNTY COALS, AIR DRIED.

Number	3070	3075
Moisture	6.47	5.03
Volatile combustible matter	34.98	36.52
Fixed carbon	50.45	41.33
Ash	8.10	17.12
Total	100.00	100.00
Phosphorus	0.00	0.00
Sulphur	2.51	2.90
Coke	42.35	58.45
Specific gravity	1.333	1.357
Color of ash	lilac	lilac
Character of coke	porous	dense
B. T. U. per lb.	*11,969	*10,880

* By Parr Calorimeter.

Owsley County Coals.

No. 2818. Coal, from D. H. Reynolds bank, 1 mile from Booneville, on Gabbard Fork, Owsley Co., Ky. Collected by A. M. Miller, 1907. Breathitt Formation. Thickness of bed, 28 inches.

COMPOSITION OF THIS OWSLEY COUNTY COAL, AIR DRIED.

Number	2818
Moisture	2.02
Volatile combustible matter	36.82
Fixed carbon	53.68
Ash	7.48
Total	100.00
Phosphorus	0.00
Sulphur	1.09
Coke	61.16
Specific gravity	1.284
Color of ash	brown
Character of coke	dense
B. T. U. per lb.	*13,415

* By Parr Calorimeter.

Perry County Coals.

No. 2732. Coal, from Lost creek, J. E. Campbell, Perry Co., Ky. Collected by J. M. Hodge. August, 1906. Thickness of bed, 58 inches.

No. 2733. Coal, from 15 mile Branch, Lost creek, Perry Co., Ky. Collected by J. M. Hodge, August, 1906. Thickness of bed, 88 inches.

No. 2734. Coal, from Old House Branch below Cutshin creek, Henry Begley, Perry Co., Ky. Collected by J. M. Hodge, August, 1906. Thickness of coal, 72 inches.

COMPOSITION OF THESE PERRY COUNTY COALS, AIR DRIED.

Number	2732	2733	2734
Moisture	2.09	2.48	1.91
Volatile combustible matter	38.61	35.51	38.29
Fixed carbon	54.21	52.43	52.45
Ash	5.09	9.53	7.35
Total	100.00	100.00	100.00

Phosphorus	0.007	0.033	0.023
Sulphur	0.83	1.05	0.73
Coke	——	62.01	59.80
Specific gravity	1.297	1.337	1.297
Color of ash	lt. buff	yellowish gray	lt. buff
Character of coke	dense spongy	dense spongy	dense spongy
B. T. U. per lb	*14,018	*12,958	*13,613

* By Parr Calorimeter.

Pike County Coals.

No. 3083. Coal, from Greenough Coal & Coke Co., Hellier, Pike Co., Ky. Collected from Upper Elkhorn seam by A. G. Spillman. Section equal 45 in.

No. 3085. Coal, Edgewater Coal & Coke Co., Hellier, Pike Co., Ky. Collected near face of main entry Lower Elkhorn seam, by A. G. Spillman. Section is, laminated coal 17 inches, coal 15 inches.

No. 3086. Coal, from Henry Clay Mine, Lookout, Pike Co., Ky. Collected from face of room No. 6 on 2d Left, Lower Elkhorn seam, by A. G. Spillman.

No. 3088. Coal, from Pike County Coal & Coke Co's. mine, Hellier, Pike Co., Ky. Collected from face of 1st right entry by A. G. Spillman. Section is, coal 45 inches.

No. 3089. Coal, from Greenough Coal & Coke Co's. mine, Hellier, Pike Co., Ky. Collected by A. G. Spillman, from near face of main entry, Upper Elkhorn seam. Section is 46 inches coal.

No. 3090. Coal, from Henry Clay mine, Lookout, Pike Co., Ky. Collected by A. G. Sillman, from face of main entry, Upper Elkhorn seam. Section is 36 inches coal.

No. 3094. Coal, from Greenough Coal & Coke mine, Hellier, Pike Co., Ky. Collected by A. G. Spillman, from 3d left air course, Upper Elkhorn seam. Section is 46 inches coal.

No. 3095. Coal, from Pike County Coal & Coke Co's. mine, Hellier, Pike Co., Ky. Collected by A. G. Spillman, from 3d left air course, Lower Elkhorn seam. Section is, coal 29 inches, laminated coal 24 inches.

COMPOSITION OF THESE PIKE COUNTY COALS, AIR DRIED.

Number	3083	3085	3086	3088
Moisture	1.70	1.67	1.75	1.70
Volatile combustible matter	33.00	32.43	33.00	35.50
Fixed carbon	60.05	64.10	62.25	61.75
Ash	5.25	1.80	3.00	1.05
Total	100.00	100.00	100.00	100.00
Phosphorus	trace	trace	trace	trace
Sulphur	0.62	0.50	0.69	0.61
Coke	65.30	65.90	65.25	62.80
Specific gravity	1.280	1.260	1.289	1.270
Color of ash	brown	brownish	brown	brown
Character of coke	porous	porous	porous	porous
B. T. U. per lb.	†13,540	†14,835	†14,185	†14,715
Number	3089	3090	3094	3095
Moisture	1.50	1.55	1.60	1.70
Volatile combustible matter	35.65	35.60	32.80	31.39
Fixed carbon	61.80	60.20	60.78	62.69
Ash	1.05	2.65	4.82	4.22
Total	100.00	100.00	100.00	100.00
Phosphorus	trace	trace	trace	trace
Sulphur	0.64	0.65	0.62	0.44
Coke	62.85	62.85	65.60	66.91
Specific gravity	1.267	1.283	1.293	1.316
Color of ash	brown	brown	brown	brown
Character of coke	porous	porous	dense	porous
B. T. U. per lb.	†14,755	†14,445	*13,570	*14,005

* By Parr Calorimeter.

† By Bomb Calorimeter.

Powell County Coals.

No. 2822. Coal, from about 1 mile from Dundee, Clear Branch, Powell Co., Ky. Collected by A. M. Miller, 1907. Sample is Coal No. 1. (Lowest coal above limestone.) Thickness of bed, 17 inches to 24 inches.

COMPOSITON OF THIS POWELL COUNTY COAL, AIR DRIED.

Number	2822
Moisture	2.96

Volatile combustible matter	37.63
Fixed carbon	43.85
Ash	15.56
Total	100.00
Phosphorus	0.00
Sulphur	4.55
Coke	59.41
Specific gravity	1.32
Color of ash	reddish
Character of coke	——
B. T. U. per lb.	*10,984

* By Parr Calorimeter.

Union County Coals.

No. 3069. Coal, from Kentucky Coal Mining Co's. mine No. 2, at Waverly, Union Co., Ky. No. 11 coal.

No. 3068. Coal, from Kentucky Coal Mining Co's. mine No. 1, at Waverly, Union Co., Ky. No. 11 coal.

No. 3159. Coal, from River and Rail Coal & Coke Co., Uniontown, Union Co., Ky. Collected by company.

COMPOSITION OF THESE UNION COUNTY COALS, AIR DRIED.

Number	3069	3068	3159
Moisture	3.73	3.30	7.20
Volatile combustible matter	39.79	39.60	39.90
Fixed carbon	46.23	41.58	46.00
Ash	10.12	15.52	6.90
Total	100.00	100.00	100.00
Phosphorus	0.00	0.00	0.00
Sulphur	3.89	4.69	3.18
Coke	36.24	26.06	52.90
Specific gravity	1.351	1.366	1.329
Color of ash	gray	gray	lilac
Character of coke	dense	dense	porous
B. T. U. per lb.	*11,720	*10,722	*12,530

* By Parr Calorimeter.

Webster County Coals.

No. 2668. Coal, from Sebree Coal Co., Webster Co., Ky. Sent by Sebree Coal Co.

No. 2788. Coal, from Wheatcroft Mine (shaft), now West Kentucky Coal Co's. Colliery G. Composite of average sample collected by A. G. Spillman, from the head of west entry and from room No. 11 on Main West Entry.

No. 3082. Coal, from Shamrock mine, Providence, Webster Co., Ky. Collected by A. G. Spillman, from near face of 2d West Entry.

No. 3084. Coal, from S. K. Luton's mine, Providence, Webster Co., Ky. Collected by A. G. Spillman, from near face of 1st left entry. Thickness of bed, 55 inches.

No. 3087. Coal, from Shamrock mine, Providence, Webster Co., Ky. Collected by A. G. Spillman, from near face of South entry. The section is coal, 46 inches, clay 2 inches, coal, 24 inches.

No. 3091. Machine dust from electric machine in shaft mine of Providence Coal Co., Providence, Webster Co., Ky. Collected by A. G. Spillman. Sample consisted of chiefly coal dust and very small lumpss of coal.

No. 3092. Coal, from S. K. Luton's mine, Providence, Webster Co., Ky. Sample collected by A. G. Spillman, from near face of Main entry. Thickness of bed, 58 inches.

No. 3102. Coal, from No. 9 seam, Providence, Webster Co., Ky.

COMPOSITION OF THESE WEBSTER COUNTY COALS, AIR DRIED.

Number	2668	2788	3082	3084
Moisture	8.87	1.16	3.70	3.31
Volatile combustible matter	40.62	37.94	40.38	36.29
Fixed carbon	45.52	51.17	49.97	51.03
Ash	4.99	9.73	5.95	9.37
Total	100.00	100.00	100.00	100.00
Phosphorus	0.00	0.00	trace	trace
Sulphur	2.29	3.91	2.72	4.44
Coke	50.51	60.90	55.92	60.40
Specific gravity	1.301	1.42	1.291	1.350
Color of ash	lt. brown	purple	lilac	lilac
Character of coke	spongy	——	porous	porous
B. T. U. per lb.	*12,709	*12,708	†12,995	†12,255
Number	3087	3091	3092	3093
Moisture	3.70	3.60	3.15	2.60

Volatile combustible matter	40.45	34.55	38.05	35.15
Fixed carbon	50.98	50.51	49.90	52.15
Ash	4.87	11.34	8.90	10.10
Total	100.00	100.00	100.00	100.00
Phosphorus	trace	trace	trace	0.00
Sulphur	2.77	3.52	3.80	4.13
Coke	55.85	61.85	58.80	62.25
Specific gravity	1.304	1.343	1.331	1.349
Color of ash	lilac	lilac	lilac	lilac
Character of coke	porous	porous	porous	porous
B. T. U. per lb	†13,365	†12,075	†12,710	†12,770

* By Parr Calorimeter.
† By Bomb Calorimeter.

Whitley County Coals.

No. 2751. Coal, from Anderson Coal Co., Halsey, Whitley Co., Ky.

No. 2796. Coal, from Mount Morgan mine, Jellico coal, Whitley Co., Ky. Composite of averages from face of No. 4 entry, and from room No. 24, on No. 11 entry. Thickness of bed, 34 and 32 inches.

No. 3058. Coal, from the Gatliff Coal Co., Williamsburg, Whitley Co., Ky. Sent by the company, May 10, 1909, and designated as "Top Bench."

No. 3059. Coal, from the Gatliff Coal Co., Williamsburg, Whitley Co., Ky. Sent by the company May 10, 1909. and designated as "Middle Bench."

No. 3060. Coal, from the Gatliff Coal Co., Williamsburg, Whitley Co., Ky. Sent by the company May 10, 1909. and designated as "Bottom Bench."

No. 3061. Coal, from the Gatliff Coal Co., Williamsburg, Whitley Co., Ky. Sent by the company May 10, 1909. and designated as "Top, Middle, and Bottom Benches." The sample is an average of Nos. 3058, 3059 and 3060.

No. 3160. Coal, from the Acme Blue Gem Coal Co., Gatliff, Whitley Co., Ky. Average sample collected by the company, July 1, 1909.

COMPOSITION OF THESE WHITLEY COUNTY COALS, AIR DRIED.

Number	2751	2796	3058	3059
Moisture	1.90	1.18	2.32	2.38
Volatile combustible matter	27.32	37.54	43.27	40.82
Fixed carbon	43.71	58.45	52.27	54.55
Ash	27.07	2.83	2.15	2.25
Total	100.00	100.00	100.00	100.00
Phosphorus	0.02	0.00	trace	trace
Sulphur	0.92	1.23	0.63	0.89
Coke	70.78	61.28	50.12	52.30
Specific gravity	1.557	1.27	1.267	1.263
Color of ash	buff	whitish	brown	brown
Character of coke	dense	lt. spongy	porous	porous
B. T. U. per lb	*10,825	*14,111	*14,120	*13,652

Number	3060	3061	3160
Moisture	2.35	2.07	2.17
Volatile combustible matter	39.98	41.73	44.13
Fixed carbon	55.72	53.92	49.90
Ash	1.95	2.28	3.80
Total	100.00	100.00	100.00
Phosphorus	trace	0.00	0.00
Sulphur	0.65	0.70	2.94
Coke	53.77	51.64	53.70
Specific gravity	1.275	1.266	1.301
Color of ash	brown	brown	lilac
Character of coke	porous	porous	porous
B. T. U. per lb.	*13,558	*13,527	†14,054

* By Parr Calorimeter.

† By Bomb Calorimeter.

Wolfe County Coals.

No. 2823. Coal, from Henry Alexander's bank near Campton. Collected by A. M. Miller. Thickness of bed 61 inches. Bed has a 6-inch clay parting, 29 inches from base of coal, 3 inches shaly coal and a 3-inch shaly streak, 7½ inches from top.

No. 2824. Coal, from Rem Allen's coal seam near Campton. Collected by A. M. Miller. Thickness of bed, 47 inches. The thickness includes clay partings reducing coal to 34 inches.

COMPOSITION OF THESE WOLFE COUNTY COALS, AIR DRIED.

Number	2823	2824
Moisture	3.30	3.25
Volatile combustible matter	36.65	36.22
Fixed carbon	52.35	47.91
Ash	7.70	12.62
Total	100.00	100.00
Phosphorous	0.00	0.00
Sulphur	2.13	0.91
Coke	60.05	60.53
Specific gravity	1.26	1.26
Color of Ash	gray	yellowish brown
B. T. U. per lb.	*12,542	*12,058

* By Parr Calorimeter.

CO-OPERATION IN MAPPING

BRIEF STATEMENT OF FIELD WORK.

Following is a succinct statement of the field work accomplished, during the calendar years 1908 and 1909, in mapping carried on in co-operation by the U. S. Geological Survey and the Kentucky Geological Survey, as given by Col. R. C. Rizer, Acting Director of the U. S. Geological Survey. The year, under the agreement between the two Surveys, for which allotments are made runs from July 1st to June 30th, but for present purposes it is believed best to present results according to calendar years.

FROM JANUARY 1, TO DECEMBER 31, 1908.

		LEVELS			TRAVERSE		
Quadrangle	Area mapped Sq. Mi.	Primary. Mi.	P.B.M's.	Secondary. Mi.	Prim'y. Mi.	Perm. Mks.	Second'y. Mi.
Princeton	238	78	12	502	....	....	868
Horsebranch	.....	....	....	....	138	22	....
Rochester	.....	....	....	....	....	....	....
Morgantown	.....	...	....	....	....	....	....
	238	78	12	502	138	22	868

Triangulation was carried on in Lewis and Rowan counties and provided partial control for the Vanceburg, Olive Hill, Quincy, and Morehead quadrangles, 8 stations being occupied and 9 permanent marks set. Triangulation for the Kentucky portion of the Williamson quadrangle was completed, and that for the east half of the old Prestonburg was commenced, 3 permanent marks being set.

FROM JANUARY 1, TO DECEMBER 31, 1909.

		LEVELS			TRAVERSE		
Quadrangle	Area mapped Sq. Mi.	Primary. Mi.	P.B.M's.	Secondary. Mi.	Prim'y Mi.	Perm. Mks.	Second'y Mi.
Dawson Spg.	238	68	12	....	....	....	765
Monticello	20	....	....	....	....	....	69
Paintsville	.....	59	17	....	....	....	....
	258	127	38		....	....	844

Triangulation was continued in Lewis and Rowan and adjoining counties, and completed such control for the Soldier, Ewing, Rectorville, Flemingsburg, and Mt. Sterling quadrangles; also for Inez and Laynesville; 25 stations being occupied and 21 permanent marks set.

EXCHAN

Kentucky Geological Survey

CHARLES J. NORWOOD, Director.

REPORT

ON THE

Progress of the Survey

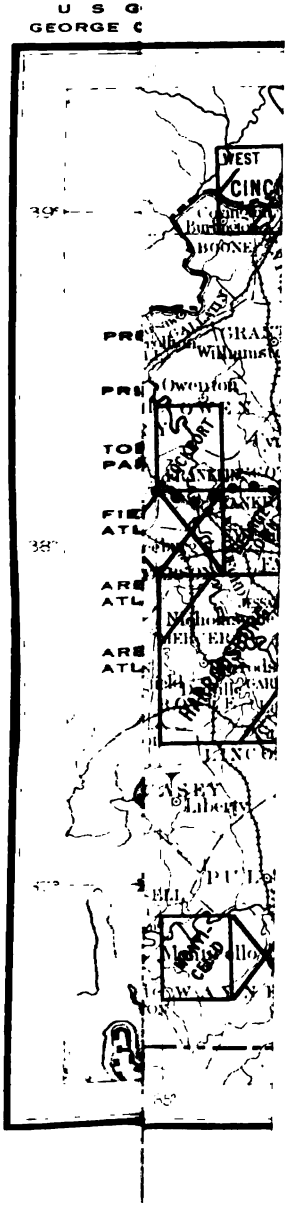
FOR THE YEARS 1910 AND 1911

By CHARLES J. NORWOOD

LEXINGTON, KENTUCKY.

1912

UNIVERSITY OF CALIFORNIA



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PERSONNEL OF THE SURVEY.

The following persons now hold or have held positions on the Survey during the period covered by this report. They are named in the order of their appointment under each class.

Director.—Charles J. Norwood.

Assistants in Geology.—August F. Foerste, Julius F. Fohs, Leonidas C. Glenn, James H. Gardner. James M. Hodge was employed in writing his report for a time in 1910. Albert R. Crandall was employed for a few months in 1910, in reproducing a report that had been lost. F. M. Hutchinson was employed in the field for a short time in 1910, and in writing his report (to which he did not give his time continuously) in 1910 and 1911.

Chemistry, Technology, and Soils.—Alfred M. Peter, supervising chemist and in charge of soil testing; Harry D. Easton, assistant in clay testing; James H. McHargue, chemist; Sadocia C. Jones, assistant in soils, and Ralph D. Quickel, (resigned February 1, 1911), aid in fuel testing.

Oil and Gas.—Kessack D. White.

Office.—F. Grider McKay, clerk; Nancy D. Bentley, stenographer.

Drafting.—Joseph W. Norwood.

Temporary Aids.—The following were employed for various periods as temporary aids in 1910: Lucian Walker, C. K. Bain, Phil Holloway, D. W. Smith, and W. B. Paynter, as field aids. R. G. Stevens, in the Museum. The following were employed in 1911 for various periods: C. E. Straub, Lucian Walker, R. M. Woodson, W. B. Paynter, as field aids. In collecting mineral statistics in co-operation with the U. S. Geological Survey the following were employed at different times (only one being employed at a time), R. G. Stevens, C. K. Bain, H. A. Kohnhorst, W. B. Hager. Mr. C. P. Kennedy is employed in keeping gage records of the Dix river.

In the co-operative topographic mapping large field parties were employed, under the direction of topographers of the U. S. Geological Survey. It is not deemed necessary to give the long list of names here.

REPORT OF PROGRESS.

Since its resumption the work of the Survey has been vigorously prosecuted along the lines laid out in the law, and many reports and maps dealing with the economic resources of the State have been completed. Reports for twenty-eight volumes known as Bulletins (some of the latter containing several reports) together with six County Reports each forming a volume, have been prepared. Unfortunately, however, the printing has by no means kept pace with the preparation of the reports and maps—a circumstance for which, of course, the Director is in no wise responsible. This matter is discussed on another page.

Manifestly, with limitations in the matter of funds available for each year, it has been impossible to at once take up all the subjects named in the law; nor has it been possible to place work each season in all the regions needing it, nor to at once comply with all requests for the examination of particular localities. The character of work that has been carried on so far has been determined not alone by personal knowledge on the part of the Director of the needs of the State, but also by the tenor of inquiries of correspondents seeking information concerning the resources of the State, by conferences with men interested in the developmnt of the State, and by some suggestions received from the late Nathaniel S. Shaler, based on his experience as Director of the Survey from August, 1873, to April, 1880, under whom the present Director served as an assistant geologist for six years.

If the older method of issuing volumes made up of miscellaneous reports were followed, the published Bulletins (as the volumes dealing with single subjects or regions are now called) on geological resources, together with the biennial reports (which contain matter relating to economic resources in addition to that relating to administration), would make five volumes of convenient size (equal to an average of 425 pages

each); and the material in the hands of printers would make about as many more.

The published Bulletins, with maps, include reports on the coals of the Big Sandy Valley, on those of the region drained by the Three Forks of the Kentucky river, on those of the Licking Valley and some of the contiguous region (including Elliott and Menefee counties), and on those along the western margin of the Eastern Coalfield. Also reports on our oil and gas horizons, on some of our clay areas, on the lead and zinc rocks of central Kentucky, on our fluorspar deposits, and on the character and economic values of some of the lower formations of the State. Reports on the coals of the Poor and Clover Forks of the upper Cumberland river (in Harlan and Letcher counties), and on those of the Pineville Gap and Log Mountains region (in Bell and Knox counties) have long been ready for publication, and have been in the printer's hands since about July 31, last. Similar reports have been prepared on a large part of the Western Coalfield; their publication has been ordered, and it is understood that arrangements have been perfected for printing them. They include reports on the coals of the region drained by the Tradewater river (about 800 square miles), on those in the region covered by the Central City, Madisonville, Calhoun, and Newberg quadrangles, and (a brief account) on those within the Hartford quadrangle. Other reports that have been prepared and are now in the hands of printers are named on another page. An elaborate report on the Cincinnatian formation, which covers so large a portion of the State, and its economic values, was prepared, but (with three others) it was lost while in the hands of a former contractor for the public printing.

Most of the reports named, while comprehensive and in considerable detail, are necessarily largely preliminary in character; they were issued to meet immediate necessities and must be followed by others giving greater detail, which, however, can be worked out only as we get accurate maps, of the sort now being made by the State and Federal Surveys in co-operation.

A new geological map of the State has been issued, also. The base for the map was compiled and drawn by J. B. Hoeing; delineation of the geological formations is in accordance with

data furnished by the various geologists that have served on the Survey under past and present administrations. Sufficient data have been gathered since publication of the map of 1907 to warrant preparation of a revised edition; indeed, it is very desirable that such an edition be issued.

Following is an account of the operations of the Survey during the two calendar years 1910 and 1911.

Geological and Technological Work.

1. *Central City, Madisonville, Calhoun, and Newberg Quadrangles.*—Field work for reports on these quadrangles, embracing an era of about 800 square miles in the heart of the Western Coalfield, was completed by F. M. Hutchinson in the spring of 1910. This work has revealed a larger number of workable coals in the upper series of beds and larger fields of thick coals than had been known to exist. The reports, forming one large Bulletin, are accompanied by maps showing the areas of the important coal beds from "No. 9" up to "No. 15," inclusive; outcrop lines are delineated, and general ground structure, including some lines of faulting, is indicated. The Bulletin was completed in 1911 and is in the printers hands, with an understanding that it is to come from the press in about four months.

2. *Rockcastle County.*—The field work for a report on the economic resources and soils of Rockcastle county was completed in 1910, the geology by F. Julius Fohs and the soil investigations by S. C. Jones, with Lucian Walker serving as field aid. The work in Rockcastle county has not only proven the richness of that county in thick and extensive beds of very high-grade oolitic and blue limestones and of "freestone," valuable deposits of clay, and great beds of sandstone that yield excellent sands for various purposes (including bottle glass), but it revealed the fact that the coal area of the southern and eastern portions of the county instead of being practically exhausted, as has been reported hitherto, still contain a large amount of good coal. It was found that the Conglomerate Sandstone measures, which carry two and sometimes three good coals, cover 53,700 acres. The average intervals between the coals, as determined by Mr. Fohs, are as follows:

The Corbin Conglomerate (72 ft.)
Interval, 91 ft.
Corley Hollow Coal..... 36 in.
Interval, 144 ft.
New Livingston Coal.....8 to 32 in.
Interval, 77 ft.
Livingston Coal..... 36 in.
Interval, 64 ft.
Mississippian Limestone and Shales. Base.

The acreage estimated for the respective seams is 40,000 for the Livingston; 28,000 for the New Livingston, and 5,000 for the Corley Hollow, of which not over 1,000 acres have been exhausted, leaving approximately 176,000,000 tons of coal yet to be recovered. Though the seams are, as a rule, thin, it is to be borne in mind that even now coals having no greater thickness are being worked in many regions, that all beds of coal are growing in value, and that these Rockcastle beds have an especial importance in connection with possibilities for the establishment of clay, cement, lime, and other industries that the resources of the county so well justify. The report has been ready since the fall of 1910, but publication delayed by circumstances that the Director of the Survey could not control (see statement about publications on another page); it is now in the printer's hands, with promise that it will be sent through the press within about four months.

3. *Lewis and Rowan Counties.*—A geological survey of Lewis and Rowan counties was completed in 1910, by F. Julius Fohs. An excellent showing is made by these counties in the way of high-grade structural stone (freestone), useful shales and clays, and road material. Favorable structure for oil and gas was also noted. More particular reference is made to the occurrences of freestone and oil and gas possibilities under appropriate heads elsewhere in this report. Much interest has been manifested in the occurrence of zinc ore in Lewis. The ore (zinc blende, sometimes partly altered to zinc carbonate) occurs in what it is known as the West Union limestone of the Niagaran series, either in the form of nodules or as a cementing material in thin seams in the brecciated beds. A special article on these zinc occurrences has been prepared by Mr. Fohs for

the Miscellaneous Bulletin for which material is in hand. The conclusion reached is that, while the ore is of good quality, it is not likely to be found in profitable quantity except locally. That any bed to be workable must be not less than three or four feet thick and carry at least 10 per cent. of ore. The region south of Concord is not deemed worthy of further prospecting; but "at Martin and in the Salt Lick valley region (four miles south of Vanceburg) further prospecting will be necessary to prove whether or not the deposits are of value, and this prospecting must be done in the more promising unweathered beds." The report on Lewis and Rowan is in the printer's hands.

4. *Pineville Gap Region.*—A report which had been prepared by A. R. Crandall and G. M. Sullivan on the Pineville Gap region in Bell and Knox counties, including the Log Mountains, Straight Creek and its branches, Stewarts Branch, and Fourmile Creek in Bell county; and Greasy, Brush, and Stinking creeks in Knox county, was lost by a former contractor for the public printing. It was reproduced by Prof. Crandall (requiring some field work in 1910), and has been in the printer's hands since about July 31, 1911.

5. *Hartford Quadrangle.*—Geological field work in the Hartford quadrangle (about 238 square miles) was completed in 1910-11, by J. H. Gardner. It is advisable that the report on that quadrangle shall form part of a Bulletin embracing at least one other quadrangle. A preliminary report with special reference to coals, oil, and gas, to serve until the detailed report for the Bulletin shall have been completed, has been turned over for publication and there is promise of its appearance by next May. While the report is condensed, it has several page maps showing areas of various coals and it will prove useful to prospectors. The work in this quadrangle has shown a larger area of workable coal in the western portion of the quadrangle than has hitherto been definitely known.

6. *Webster County.*—Geological field work in the Webster county area—an area typical of disturbed regions within the Western Coalfield—was completed by L. C. Glenn in 1910-11. The report is not quite ready for publication. Because of the increasing interest in this important region, concerning which there is little accurate information available in printed

form, a brief abstract from those portions of the report dealing with stratigraphy, structure, and economic resources is given in this report.

7. *Region of the Quicksand Creeks.*—Field work for a report on the coals of the region drained by the Quicksand creeks, lying in Breathitt and parts of Knott and Floyd counties, was completed by Mr. Fohs in 1911. The report is in the hands of the printer and is expected from the press within about four minths. The region covers an area of approximately 130,000 acres (about 203 square miles) in which occur eleven beds of coal, including cannels. Mr. Fohs reports the net thicknesses of the coals, with the average intervals between beds, as follows:

Hindman Coal (uppermost bed).....72 inches
Interval, 60 ft.
Flag Coal .....36 inches.
Interval, 60 ft.
Hazard Coal .....72 inches.
Interval, 145 ft.
Leatherwood Coal. Thin.
Interval, 47 ft.
Haddix Coal .....36 inches.
Interval, 68 ft.
Dean (or Fireclay) Coal.....33 inches.
Interval, 45 ft.
Wilson Fork Coal.....36 inches.
Interval, 12 ft.
Whitesburgh Coal .....30 inches.
Interval, 70 ft.
Big Branch Coal .....24 inches.
Interval, 58 ft.
Roundbottom Coal .....24 inches.
Interval, 30 ft.
Elkhorn Coal .....24 inches.

Except on the head of Quicksand creek, on Middle and Laurel forks, where the strata dip southeast at the rate of about 16 feet per thousand feet, the beds are practically horizontal. The quantity of recoverable coal in the region is estimated as 936,000,000 tons.

8. *Beattyville Coal Area.*—A partial examination of the Beattyville coal area was also made by Mr. Fohs. This coal (ranging from 10 to 50 inches in thickness, with an average of 36 inches) underlies more than half of Lee county. The following interesting statement has been presented by Mr. Fohs: "Bells account for the local thinning of the coal, and are of two types: (a) gondola-shaped, 6 to 15 feet wide and 20 feet long, and (b) large, flat-boat-shaped, up to 100 feet wide and 1,000 feet long. Both types have nearly an east-west strike, so that a north-south cress-cut would usually pass through the thin coal with the least expense. The bed is also subject to rise and fall due to bending of the strata, but this is independent of the thinning of the coal; the small folds appear every 400 to 800 feet and have a general north-northwest trend."

9. *Oil and Gas.*—Considerable work was done in the study of oil and gas possibilities in several parts of the State. In the progress of the work in the area drained by the Quicksand creeks, favorable structure was found in Yellow mountain, at the head of the Laurel fork of Quicksand, in Floyd and Knott counties. The mountain represents an anticlinal fold striking north-northeast, the west limb of which ,according to Mr. Fohs, has a dip of 16 feet per 1,000 feet, while the dip of the east limb is still greater. The elevation of the Elkhorn coal at the head of Laurel is about 1,097 feet, while, according to Crandall, in the valley to the east, at the Jones fork of Right Beaver, it has dropped to 700 feet. In Lewis and Rowan counties two monoclinal folds occur. The following note on the folds has been presented by Mr. Fohs, in whose hands the study of the geology of the counties was placed: "One of the folds passes southward from just west of Carrs, east of Ribolt, Tolesboro, and Burtonville, and strikes N. 37 degrees E.; the first likely oil or gas horizon here would be the Lexington limestone. Further east is the northward extension of the Ragland monocline, which passes between Farmers and Freestone, near Munson, between Stricklett and Awe, just east of Randville, and one mile east of Vanceburg. This monocline strikes N. 24 degrees E., and, with the surface rock Waverly, offers a number of good horizons at which oil or gas may have accumulated—notably, the Corniferous, Clinton, and Lexington formations." Investigations were made along the Rough

Creek anticline and in the Diamond Springs belt, in Western Kentucky, by J. H. Gardner and K. D. White, assisted by Lucian Walker. The Rough Creek anticline is a disturbance that stretches quite across the Western Coalfield and probably forms part of a line of disturbance that extends in a variable approximately east-west course across the State. It is believed that the work of the Survey will render it possible to avoid errors that have hitherto been made in locating points for drilling along the anticline. As the result of his studies of the region crossed by the uplift in Ohio county, Dr. Gardner advised drilling a deep well where favorable structure was noted by him, and such a well is going down. On January 4, 1912, oil was struck at 370 feet, and in such quantity as to give promise of a good productive well. In the course of his work in Webster county, very favorable structure, in the form of an elongated dome just south of Sebree, was discovered by Dr. Glenn. Dr. Glenn's description of the dome is given in the abstract from his report included in this report. To Mr. White was assigned the task of carefully working out the details of the dome, by means of an instrumental survey and the preparation of a contour map of the structure, and this he has performed in an excellent way. His report (Oil and Gas Prospect of the Rough Creek Anticline at Sebree) is ready for publication. A contour map of the structure of the Diamond Springs district, in Logan county, has also been made by Mr. White, the stratigraphy being worked out largely by Dr. Gardner. The work there has shown that the failure of some of the wells that had been drilled may be accounted for, if in no other way, by the fact that they were not properly located with reference to the structure as determined by the Survey. The report on the Diamond Springs belt, with accompanying structure map, is nearing completion. In cooperation with the U. S. Geological Survey, investigations were also made in Wayne, Powell, Wolfe, and Menefee counties. A report on the Wayne county field, by M. J. Munn, of the Federal Survey, who had charge of the work, is expected to be ready for publication by about the middle of February. A report on oil and gas in the Central City, Madisonville, Colhonnave and Newberg quadrangles, by F. M. Hutchison, is ready for publication.

10. *Mapping the Elm Lick Coal.*—One of the most important pieces of work undertaken in 1911 was the tracing and mapping of the outcrop of the Elm Lick coal in Ohio and Butler counties, with connections in Daviess. This work owes its importance chiefly to the fact that a key has thus been obtained for the solution of some difficult problems in connection with occurrences of coal in the eastern part and along the eastern margin of the Western Coalfield that for years have given trouble to persons interested in the mining industry. The work was placed in the hands of J. H. Gardner and K. D. White, who were assisted by Lucian Walker. The mapping began at Horton (formerly Elm Lick), in Ohio county. In a brief memorandum concerning the work, Dr. Gardner states: "Our first problem was to trace this coal bed, which had been noted and named by you in an early report, from Horton southeastward toward Butler county. We were able to follow the continuous outcrop of this bed to Morgantown, in Butler county, and to positively connect it with the coal bed which is being mined at Aberdeen. This was a contribution to knowledge and rather surprising in correlation. It affords a key to map the geology of Butler county and adjacent regions on the new topographic sheets which are being prepared in that section of the State. . . . While at Morgantown, we visited the Mud River mine in Muhlenberg county, and were of the opinion that the coal mined there is the same as the Elm Lick, in position." Returning to Horton the party traced and mapped the coal northward until it thinned out north of the Rough Creek Uplift. It had been supposed that the Elm Lick would correlate with the Deanefield coal, but Dr. Gardner reports; "We proved that it is not the same as the Deanefield coal, which extends into Daviess county, but that the latter is the next lower bed named the Hamlin coal in my section of Ohio county. The Elm Lick coal as traced over the territory outlined is very irregular in character, and will average less than 3 feet in thickness, very rarely approaching 4 feet. It is, however, an important reserve supply in the coal resources of West Kentucky." The mapping was done by Mr. White; the stratigraphy by Dr. Gardner. As the coal was traced southward marked evidences of erosion and unconformity were noted at the horizon of the bed, as had long been known to occur at

the horizon of the Aberdeen coal. Mr. White has correlated the Elm Lick with the "No. 5" coal as identified south of Sebree, in Webster county, by Dr. Glenn. If this be correct, it places the Elm Lick coal near the top of the Tradewater formation (a formation unit proposed by Dr. Glenn), where there is also a marked unconformity. The writer understands that from fossil evidence submitted to him, Mr. David White, of the U. S. Geological Survey, assigns the Elm Lick coal to Pottsville age.

11. *Field work on the Henderson quadrangle* was begun in 1911. The area has not been completely mapped, and the geological work is difficult because of lack of outcrops.

12. *Along Transportation Lines.*—Field work for a series of short reports on the economic resources adjacent to the railroad lines of the State was entered upon in 1911. The work was completed along the lines in the Jackson's Purchase region, to which Dr. Gardner was assigned; along the Louisville & Nashville railroad, from Louisville southward to the Tennessee boundary, to which Mr. Fohs was assigned; and along part of the Chesapeake & Ohio railroad. The report on the line of the Louisville & Nashville railroad has been prepared. This work has revealed the presence of greater values in conomic resources along that line than had been known. Three short abstracts from the report of Mr. Fohs—on the Bowling Green stone industry, on honestone for marble in Hardin county, and on onyx-marble—have been prepared for publication in leaflet form. The report on the lines in the Purchase region is yet to be completed. Continuation of this work until all the railroad lines of the State have been traversed is one of the plans of the Survey.

13. *The Dix River Drainage and Water Power.*—The value of the Dix river as a source of water power was investigated in 1910-11. The drainage basin embraces an area of about 432 square miles, in Boyle, Garrard, Mercer, Lincoln, and Rockcastle counties. The economic resources of the region were also noted. The work was placed in the hands of Dr. August F. Foerste. The report has been turned over to the printer and is expected to come from the press within about four months.

14. *Phosphate Rock.*—The rock phosphate deposits of

central Kentucky were investigated by Dr. Foerste in 1911. A surprisingly large area of available commercial phosphate was determined. The report is in the hands of the printer.

15. *Clay Deposits.*—Investigations of the clay deposits has been continued, and much matter for an additional bulletin on clays has been gathered. The excellent plastic fireclay of Rockcastle county occurs at the horizon of the New Livingston coal, in beds each 4 feet to 6 feet in thickness above and below the coal where the latter is thin. The more notable occurences are in the region between Mt. Vernon and Pine Hill, and south and southeast of the latter place. In his report on the county, Mr. Fohs estimates that in the region indicated there are about 3,800 acres of the clay, and that if the average thickness, exclusive of the 8 to 10-inch coal, be taken as 6 feet, there are over 11,000,000 tons of the clay. Technologic tests of very many carefully collected samples of clay, from various parts of the State, have been made by H. D. Easton, and a report of the work that has been done is nearing completion.

16. *Stone for Structural and Other Purposes.*—Reference has been made to the occurrences of valuable deposits of stone for various purposes in Rowan, Lewis, and Rockcastle counties, and in the region adjacent to the line of the Louisville & Nashville railroad, as noted in the reports of Mr. Fohs that have been prepared within the period covered by this report. It is believed that brief notes concerning them, given here, will prove useful: *Kentucky freestone or "bluestone,"* a high class building stone, occurs at two horizons in the Waverly group—one in the Buena Vista beds at the base of the Cuyahoga formation, and the other (the Hummel bed of Rockcastle county) just above the Cuyahoga, in the upper Waverly. The first offers excellent quarry locations in Lewis and Rowan counties, and the stone is being quarried between Morehead and Farmers, adjacent to the Chesapeake & Ohio railroad. The stone occurs in beds 16 to 30 inches in thickness, three or four of which grade as of first quality and a number as of second quality. The Hummel bed has an average net thickness of 6 feet, and presents an accessible outcrop line of about five miles between Langford and Wildie in Rockcastle county—offering over 15,000,000 cubic feet of stone if a quarry width of only 100 feet be counted. *Oolitic limestones* are receiving much at-

tention. From two to four oolitic beds of excellent quality have been found to occur in the Ste. Genevieve-St. Louis formation on both sides of the Cincinnati geanticline. A systematic sampling of this series of limestones in Rockcastle county was accomplished, and beds adapted to nearly all purposes for which limestone may be used were found. The most important of the beds are the Sparks or upper oolitic bed, 10 to 31 feet thick, and the Mt. Vernon or lower bed, of similar character, 8 to 17 feet thick. Either of them is excellent for building stone, open hearth flux, etc. These limestones are found presenting an outcrop line of about twelve miles adjacent to the Louisville-Norton branch of the Louisville & Nashville railroad, between Maretburg and Sinks. In Hardin county, three miles southeast of Elizabethtown, a deposit of fine white oolitic limestone, 12 feet thick, was noted, which is twelve miles nearer to Louisville and eastern markets than is the Bedford stone. Excellent beds were also seen in the vicinity of Upton, adjacent to the railroad, and also at Horse Cave and at Cave City. The beds reach their greatest development in the Bowling Green region, where, instead of one quarryable bed, there are four, each showing a thickness of from 10 to 16 feet of net, massive, oolitic limestone. In this region four areas, easily accessible to river and rail, offer, under very little cover, approximately 128,000,000 cubic feet of excellent building stone. One of the beds, newly opened, is an unusually beautiful white oolite, readily carved and yet of good strength. These oolitic limestones are quarried at a cost of 15 cents per cubic foot and bring in the rough from 30 to 65 cents. *Veined decorative marbles*, suitable for interior purposes, in yellow, pink, and gray colors, occur in the Bowling Green region and in the vicinity of Cave City; they are to be had in beds from 3 to 15 feet in thickness. *Onyx-marble,* worthy of exploitation, is offered by the hundreds of caves in the Cave City and Glasgow Junction region. The good stone has an average value of $3.00 per cubic foot undressed, and costs only $1.15 to produce. *A honestone for marble*, an unusually fine-graded, porous, crystalline magnesian limestone bed occurs in the St. Louis formation in Hardin county. It is one of the two American "marble honestone" deposits marketed, and should find an extended use in pulverized form for polishing soft metals; and it

should replace the harder, merely scratching volcanic dust now used in household cleaners and in scouring soaps.

17. *Material for a Miscellaneous Bulletin* has been prepared. It includes notes on occurrences of asphalt rock in various parts of the State; on the different forms of calcium carbonate for making whiting; on the properties and applications of calcite whiting; on the great calcite vein in Mercer county and other similar deposits; on lithographic stone; on building stones; on the zinc rocks of Lewis county; and on some of the special sorts of calcareous stones of the State.

18. *Barytes Deposits.*—Study of the barytes deposits of central Kentucky has been completed and the report is nearing completion. This work is in the hands of F. Julius Fohs. The Survey has proved this to be the greatest barytes district in the United States. The available tonnage is enormous. There are near to 150 veins. The veins frequently have a linear extent of three and five miles, the average length being one mile, and the workable barytes extends to an average depth of about 250 feet. Until the Survey undertook this investigation, comparatively little was known concerning the value of our barytes deposits; indeed, Kentucky was not even mentioned as a source of commercial barytes in publications dealing with the mineral. Some mining was done years ago in one of the veins in Henry and Owen counties, and in Franklin county, but it was solely for the purpose of obtaining lead, and results were not, upon the whole, remmerative. Mining primarily for the barytes, with lead and zinc as a by-product, is now carried on in a number of localities. Two plants for preparing the mineral for market are in operation, and there is reason to expect that an additional one will be built at an early day. The writer believes that these are merely the pioneers of what will eventually prove to be a great Kentucky industry founded on these deposits.

19. *Calcite Deposits.*—Investigations of the calcite deposits were carried on co-incident with the work on barytes. As one result of the investigation a profitable industry, in the production of a very high grade of calcite whiting, has been established.

20. *Soil Work.*—Soil surveys were made in Webster, Ohio, Madison, and Rockcastle counties in 1910, and in the

Big Sandy Valley, in Henderson county, in Leslie county, and in Perry county in 1911. This work, which is in the hands of S. C. Jones, is carried along lines that are of real, practical value to the farmer. The field work is conducted by the Survey alone and the laboratory work (including pot culture experiments) by the Survey and the State Agricultural Experiment Station in cooperation. A valuable preliminary report of the results of his investigations during the past two years has been prepared by Mr. Jones, for this report, but it is thought best to present it as a separate. A brief statement concerning the soils and agricultural possibilities of the Eastern Coalfield, prepared by Mr. Jones and based on his work in that field during the past season, is included in this report in the hope that its early publication may prove helpful to those who are interested in the agricultural aspects of that rapidly advancing region.

21. *Soil Bulletin.*—Material for a Soil Bulletin has been prepared. It includes reports and papers as follows: The geology of Kentucky soils; a practical way to supply plant food to our soils; soils of the St. Louis and Chester formations as represented in Meade and Breckenridge counties; soils of the St. Louis and Waverly formations as represented in Adair, Green, and Taylor counties; ground limestone for improving soils; soil survey of the Marrs farm in Henderson, a study of the character and needs of certain sorts of defective farmlands in the Western Coalfield; effect of ground rock phosphate on Kentucky soils; soils of the Hartford quadrangle; soils of Rockcastle county; soils of the Webster county area; a study of soil types in Madison county; and the phosphate rocks of central Kentucky.

22. *Chemical Work.*—Several hundred analyses have been made in the chemical laboratory of the Survey. The samples analyzed include not only those collected by the Survey, but a great number that have been sent in by citizens throughout the State. No charge is made for analytical work done for citizens of the State, and every effort is made to furnish results within a short time. Unfortunately, however, the chemist (whose hands are always full) can not always analyse the samples sent in as soon as the persons sending them de-

sire, and this has caused the Director to receive some unpleasant communications in regard to the matter.

Topographic Mapping.

Mapping of the State, which is being carried on in cooperation with the U. S. Geological Survey, is being pushed as rapidly as possible. Each organization bears half of the expenses of field and office work. For the $10,000 per annum expended by Kentucky the State receives more than $20,000 in the way of results, since the Federal Survey engraves and prints the maps without cost to the State. The mapping is done according to quadrangles, each of which includes an area (varying according to location) of about 238 square miles.

In the Eastern Coalfield, where accurate contour maps are greatly needed—are, indeed, absolutely required before detailed geology (such as mapping the outcrop lines, and thus determining the areas, of important coals) can be taken up properly—much time has been consumed in making the triangulation and running primary levels and traverse necessary before the final topographic work can be undertaken. A large portion of the field, together with an area which includes Lewis and Rowan counties, has been triangulated and primary "control" obtained, and detailed topographic work has been taken up. In the Western Coalfield the obtention of preliminary control is less difficult than in the more rugged Eastern one, and more rapid progress has been made in completing topographic sheets. Several quadrangles outside the coal fields have been surveyed, and the sheets published, but it has seemed best at this time to place most of the mapping in the coal fields and the oil and gas fields, where accurate maps are indispensable for accurate geologic work. About twenty maps made in cooperation have been published.

The field work for the following quadrangles has been completed within the last two years: The Nortonville, including parts of Muhlenberg, Hopkins, and Christian counties, area 238 square miles (map published); the Drakesboro, including parts of Muhlenberg, Todd and Logan, area 238 square miles; the Berrys Lick or Rochester, including parts of Muhlenberg, Ohio, Logan, and Butler, area 238 square miles; the Little

Muddy or Morgantown, including parts of Butler, Warren, and Logan, area mapped 171 square miles (nearly completed); the Monticello, including parts of Wayne, Russell, and Clinton, area mapped 108 square miles (completed); the Crockettsville, including parts of Breathitt, Perry, and Leslie, area 237 square miles; the Troublesome, including parts of Breathitt, Perry, and Knott, area 237 square miles. Such field work was done in the Lagrange and Taylorsville quadrangles as was necessary to complete the map of Jefferson county. In the course of the work, as reported by the director of the U. S. Geological Survey, 1,555 square miles were mapped; 514 miles of primary levels were run; 152 permanent bench marks were set; and 5,533 miles of secondary traverse were run. To this must be added the areas covered by triangulation.

The topographic mapping is carried on under the supervision of W. H. Herron, Geographer in charge of the Central Division of the U. S. Geological Survey. An account explaining in detail cooperative methods of topograpic surveys and the results of primary leveling, triangulation, and primary traverse, during the past two seasons, together with an index map of Kentucky, has been prepared by Mr. Herron; this will be presented for publication as a separate.

Publication of Reports.

The Survey has been greatly embarassed in its work through failure to get its reports printed within reasonable time—a matter quite beyond the control of the Director. Attention was called to this in the last Biennial report. Delays on the part of contractors for public printing have not only held up the publication of reports long after their preparation, but they have subjected the Survey to criticism that it has not in any way deserved; moreover, these delays have compelled the Director to give much time to the preparation of special matter relating to regions inquired about, to meet the requirements of correspondence, that should have been available for other matters, including field work. An accumulation of unprinted reports has resulted from such delays, but it is now hoped that, in consequence of arrangements that have been made recently by the Superintendent of Public Printing, the accumulated re-

ports will go through the press within the next four months, and that reports now in course of preparation will be published within proper time.

To in some degree compensate for delays in printing the complete reports, it is proposed to hereafter issue leaflets and press letters from time to time, to such extent as the resources of the Survey will permit and the Governor approve.

Following is a memorandum of reports in the hands of printers, reports ready for publication but reserved, and reports in course of preparation:

In the Hands of Printers.

No. 16. Bulletin 13. The coals of the Poor and Clover Forks of Cumberland River in Harlan and Letcher counties. By J. M. Hodge. (In printer's hands since July 31, 1911.)

No. 17. Bulletin 14. Coals of the Pineville Gap Region in Knox and Bell counties. Includes the Log Mountains, Yellow and Browning Creeks, Straight Creek and its branches, Stewarts Branch, and Fourmile Creek in Bell; and Greasy, Brush, and Stinking Creeks in Knox. By G. M. Sullivan and A. R. Crandall. (In printer's hands since July 31, 1911.)

No. 18. County Report 1. The mineral veins and other resources of Livingston county. By R. H. Loughridge; revisions up to 1910 by F. J. Fohs. This report, with three others was lost after it had been placed in the hands of a former contractor for public printing. Reproduced in 1910-11.

No. 19. Bulletin 15. General Report on the Lead, Zinc, Fluorspar, Barytes, and Calcspar Region of Western Kentucky, in Caldwell, Crittenden, Christian, Livingston, Lyon, and Trigg Counties. By F. J. Fohs. This report was lost after it had been placed in the hands of a former contractor for public printing. Reproduced in 1910-11.

No. 20. County Report 2. Geology and Soils of Adair, Green, and Taylor Counties. Geology by A. M. Miller. Soils by S. C. Jones. (Ready since 1909.)

No. 21. Bulletin 16. The Waverly Formations of East Central Kentucky, and their Economic Values, in Lewis, Greenup, Carter, Rowan, Bath, Menefee, Montgomery, Powell, Morgan, Estill, Fleming, and Clark Counties. By W. C. Morse and A. F. Foerste. (Ready since December, 1909.)

No. 22. County Report 3. Report on the Economic Re-

sources of Lewis and Rowan Counties. By F. J. Fohs. (Ready since 1910.)

No. 23. County Report 4. Report on the Economic Resources and Soils of Rockcastle County. Geology by F. J. Fohs. Soils by S. C. Jones. (Ready since 1910.)

No. 24. Bulletin 17. Geological Reconnoissance of the Region Drained by the Tradewater River, with special reference to coals. Embraces parts of Union, Webster, Hopkins, Christian, Crittenden, and Caldwell counties. By L. C. Glenn. (Ready since 1910.)

No. 25. Bulletin 18. Coals of the Region Drained by the Quicksand Creeks, in Breathitt, Floyd, and Knott Counties. By F. J. Fohs. (Ready in 1911.)

No. 27. Bulletin 20. Preliminary Report on the Economic Geology of the Hartford Quadrangle, together with a report on the soils. Geology by J. H. Gardner. Soils by S. C. Jones. (Made ready in 1911.)

No. 28. Bulletin 21. The Value of Dix River as a Source of Water Power. By A. F. Foerste. (Made ready in 1911.)

No. 29. Bulletin 22. Geology of the Central City, Madisonville, Calhoun, and Newberg Quadrangles, in Muhlenberg, Ohio, Hopkins, McLean, Webster, Daviess, and Henderson Counties. By F. M. Hutchinson. Four reports in one Bulletin. (Made ready in 1911.)

Ready for Publication But Reserved.

The following are reserved until progress is made on other reports now in the hands of printers, or for other reasons given:

No. 26. Bulletin 19. General Account of the Natural Resources of Kentucky. (It is desired to use some of the plates that have been prepared for reports already noted.)

No. 14. Bulletin 8. Key to the State Geological Map. (This has been ready so long that, since it is desired to get out a new edition of the map, it is held for revision to suit such map. If a new map cannot be issued, the Key will be printed as it now stands.)

No. 30. Bulletin 23. Soil Bulletin. (In cooperation with State Agricultural Experiment Station.) The contents of this Bulletin have been given in paragraph 22 on a preceding page.

No. 31. Bulletin 24. Miscellaneous. The contents of this Bulletin have been given in paragraph 17 on a preceding page.

Reports in Course of Preparation.

1. Commercial Values of Kentucky Clays, as Determined by Kiln Tests and Otherwise, from Various Parts of Kentucky. By H. D. Easton. (This Bulletin, nearing completion, is the result of a long series of technologic tests by Prof. Easton.)

2. The Soils and Agricultural Conditions of the Big Sandy Valley. By S. C. Jones.

3. Study of a Typical Area of Mountain Soils in the Region Drained by the Three Forks of the Kentucky River, as Represented by Perry and Leslie Counties, with a Discussion of the Agricultural Possibilities of that Region. By S. C. Jones.

4. A General Discussion of the Soils of Kentucky. By S. C. Jones.

5. A General Discussion of the Coals of the Eastern and Western Fields, with analyses and determinations of calorific values. By C. J. Norwood.

6. The Barytes Deposite of Kentucky. By F. J. Fohs.

7. The Coals and Other Resources of Webster County, an area representative of varied structural conditions encountered in the Western Coalfield. By L. C. Glenn.

8. Oil and Gas Bulletin No. 2. Includes: Oil and gas along the Rough Creek Anticline, in Ohio county, by J. H. Gardner; the Diamond Springs Oil and Gas District, by J. H. Gardner and K. D. White; the Sebree Dome as a Possible Source of Oil and Gas, by K. D. White (ready); Errors that Have Been Made in Drilling Along the Rough Creek Anticline, by K. D. White; Oil and Gas in the Central City, Calhoun, and Madisonville quadrangle, by F. M. Hutchinson (ready).

9. The Phosphate Rocks of the Midway District. By A. F. Foerste.

10. A General Account of the Structural Materials of Kentucky. By C. J. Norwood.

11. Study of the Elm Lick Coal and Its Outcrop Line. Stratigraphy by J. H. Gardner; map by K. D. White.

12. Study of the Wayne County Oil District, with Some

Notes on Other Kentucky Fields, by M. J. Munn. (In co-operation with the U. S. Geological Survey.)

13. Bulletin on Resources Along Transportation Lines. Includes: (a) Along the Louisville & Nashville Railroad, from Louisville to the Tennessee Line, by F. J. Fohs. Is ready. (b) Along the Railroad Lines in the Jackson's Purchase Region, by J. H. Gardner.

Projected Work.

Projected work includes continuation of investigations in the coal fields; continuation of work along transportation lines, and of investigations of clays in field and testing laboratory; investigation of mine gases and dusts; study of the streams, including, if it can be arranged, co-operation with the State Board of Health in the study of stream pollution; investigations of materials for road-building, and of structural materials, including stone, cement rock, and sands; and continuation of the oil and gas surveys, of the soil surveys, and of topographic mapping. Such county work will be taken up within the ensuing season as conditions will permit.

Disbursements.

The Survey is credited with its appropriations according to fiscal years ending June 30th, but the Director's reports of expenditures are required to be checked with the Auditor's books according to quarters of the calendar year. The following report of expenditures, showing "amounts expended, under proper heads, and for what purpose," is therefore, made up according to calendar years.

DISBURSEMENTS CALENDAR YEAR 1910.

Geology, including oil and gas surveys.	
Salaries	**$4,908.01**
Field and allied expenses	**1,388.74**
Total	**$6,296.75**
Soil Investigations.	
Salaries (exclusive of geologists)	**$1,179.98**
Field expenses	**398.16**
Total	**$1,578.14**

Chemistry and Chemical Laboratory.	
Salaries	$1,800.00
Apparatus and Supplies	403.71
Total	$2,203.71
Technology of Clays.	
Salaries	600.00
Fuel Testing.	
Salaries	$150.00
Office.	
Salaries (clerk, stenographer, and janitor)	$1,680.00
Supplies, postage, telegrams, telephone, P. O. box rent.	113.24
	$1,798.24
Drafting.	
Salary	$1,200.00
Museum.	
Temporary aid at various times, labor at various times, repairs to cases, and supplies (soap, mops, etc.)	$211.20
Equipment and Repairs and General Supplies.	
Repairs to barometers, multigraph, tables	$363.70
Freight, cartage, and expressage	$84.31
Director.	
Pay at $25 per month	$300.00
Traveling expenses	19.32
	$319.32
Co-operative Mapping.	
Salaries, subsistence, and miscellaneous field expenses	$6,530.79

DISBURSEMENTS CALENDAR YEAR 1911.

Geology, Including Oil and Gas.	
Salaries	$6,055.65
Field and allied expenses	1,645.19
Total	$7,700.84
Soil Investigations.	
Salaries	$1,196.97
Field expenses	363.92
Total	$1,560.89

Chemistry and Chemical Laboratory.	
Salaries	$1,800.00
Supplies and apparatus	141.64
Total	$1,941.64
Technology of Clays.	
Salaries	$600.00
Fuel Testing.	
Salary	$25.00
Stream Gaging.	
Pay of gager, 6 months	$48.00
Office.	
Salaries (clerk, stenographer, janitor, and temporary aid)	$1,815.00
Supplies, postage, P. O. box, telephone, telegrams	123.65
Total	$1,938.65
Collecting Mineral Statistics in co-operation with U. S. Geo. Survey.	
Pay of aid	$225.00
Drafting.	
Salary	$1,200.00
Museum.	
Repairs to cases, molding for hanging pictures, labor at various times, supplies	$134.20
Equipment, Repairs and General Supplies.	
Repairing transit, adjusting typewriter, field books, drawing paper, tracing cloth, blue-print papers, oil for clay kiln, window shades, drawing ink, and similar items	$114.43
Freights, cartage, and expressage	$45.81
Director.	
Pay at $25 per month	$300.00
Traveling expenses	41.88
Total	$341.88
Charged Against the Survey by error of Auditor's Office.	
Engraving and printing maps for Bulletin 12	$91.00
Printing blanks for Inspector of Mines	9.46
Total	$100.46
Mapping in Co-operation with U. S. Geo. Survey.	
Salaries, subsistence, and miscellaneous field expenses.	$13,441.71

THE GEOLOGY OF WEBSTER COUNTY.

Abstracts from Report of L. C. Glenn.

(It is due Dr. Glenn that it should be said he prepared a very full abstract of the first part of his report for this Biennial Report. It has seemed best, however, to keep this report within narrower limits than would be possible were the complete abstract used. Therefore, only those parts of his abstract that deal with Stratigraphy, Structure, and Economic Geology are inserted here. The part relating to stratigraphy has been condensed, and some minor matter relating to structure ("Minor Folds and Faults") has been summed up in a few words, but the part relating to economic resources is given in full, as written by Dr. Glenn.—C. J. N.)

Webster county lies wholly within the coal field of Western Kentucky. It is north of Hopkins and immediately south of Union and Henderson counties. The Rough Creek anticline, which crosses northern Webster, and the Webster synclinal basin, farther south, affect the depth of the coal beds so that near the former they may occur in outcrop or at shallow depths, while to the southwestward, near the center of the basin, some of the coals lie at depths at present too great for them to be mined.

STRATIGRAPHY.

It is important to note in the subjoined section that the workable coals, the chief economic resource of the county, are confined to the Tradewater formation, which includes the Bell and "No. 5" coals, and to the Mulford formation, which carries the "No. 9," "No. 11," and "No. 12" beds. It is also important to note the unconformities which locally affect the Baker, the "No. 9," and the "No. 11" coals.

General Section.

	Feet.
Recent:	
Alluvium deposits along stream beds.	
Pleistocene.	
Graves Creek formation: Fine or mucky clay and sand gravel	100-175
Pliocene.	
Union formation: Yellowish or brownish loam, locally a typical loess (with land shells)	8-20
Lafayette formation: Chert and quartz gravels cemented by ironstone crusts; provisonally correlated; a few feet.	
Marked unconformity; formations above frequently absent.	
Pennsylvanian Series.	
Dixon formation: Calcareous shale containing a 20-foot limestone bed constitutes the upper 150 to 250 feet. Vandersburg sandstone, fine-grained and of variable character, possibly 25 feet. Shales 80 to 100 feet. Dixon sandstone, fine-grained and of variable character, 10 to 25 feet; rarely 50 to 60 feet. Total thickness, with thin coals of no present value, about	340
Unconformity.	
Lisman formation: Chiefly soft shale, sometimes colored and calcareous, with some sandstone and thin limestones (including the Madisonville limestone), with the Anvil Rock sandstone—ferruginous coarse to conglomeritic and cross-bedded—10 to 55 feet thick, usually at the base, but absent between Clay and Wheatcroft, where shale containing the Baker coal forms the base. Total thickness	900-1000
Marked unconformity. Possibly responsible for the presence or absence of the Baker coal.	
Mulford formation: Chiefly shale, but contains important coals. Beginning at top: Shale 10 to 30 feet (rarely 125 to 150 feet) with a thin limestone at the base. *Unconformity*, which causes absence of No. 11 coal; in the Clay and Sebree regions. No 11 coal; shale except in southwestern Webster, where a prominent sandstone occurs near the base, 90 to	

100 feet. *Unconformity*, responsible locally for the absence of 20 to 30 feet of shale and the occasional cutting of channels 50 to 75 yards across into No. 9 coal. Total thickness, 250 feet (east of Providence) and 146 feet (at Sebree); usually.....	150
DeKoven formation: Shales, thin sandstones, and thin (unworkable) coals. At the base is the Sebree sandstone, coarse and massive, 10 to 50 feet thick. Formation is of variable thickness—100 feet in the Sullivan-Providence region, thickening to 151 feet at Sebree, and to 398 feet further north, at Tilden. Thickness	100-400
Marked unconformity.	
Tradewater formation: Principally shale with occasional inconstant sandstone beds. Includes No. 5 coal near top and the Bell coal near the base. Thickens from 175 feet at Sebree, in eastern Webster, to 700 feet in western Union and western Webster. Thickness	175-700
Caseyville formation: Coarse, cross-bedded, conglomeritic, cliff-forming sandstones in 20-foot to 60-foot beds alternating with thin beds of shale (up to 20 feet thick), containing thin (usually valueless) coal seams. Thickness, about	200
Marked unconformity.	
Mississippian Series.	
Lockhart-Leitchfield formations: Fine grained fossiliferous limestones and fine-grained quartzitic sandstones. Exposed	200

Beneath the Lockhart-Leitchfield formations are lower-lying Mississippian limestones, sandstones, and shales; Devonian shale; and Silurian rocks, the coarsely porous beds of which, under suitable structural conditions, may yield oil and gas.

The surface of the county is a succession of lowlands and uplands, with the former predominating. At the southwestern margin of the county, along Tradewater river, is a narrow strip of lowland underlaid by the Tradewater formation and bordered on the northeast by an upland belt of three parallel ridges of harder rock. Near the base of the first ridge, which is characterized by the upper Tradewater and DeKoven formations, is the No. 5 coal, while the second ridge, characterized by

the Mulford formation, has the No. 9 coal at its base. Coal No. 11 is near the base of the third ridge. These three sandstone-capped ridges run southeastward across the county, from near Sullivan or Wheatcroft to Providence and beyond. Next is a lawland trending northeast across the county, several miles wide between Clay and Lisman; it is characterized by the Lisman formation and Baker coal. Northeastward, a broad upland belt crosses the center of the county and includes the towns of Dixon and Vandersburg; it is characterized by the Dixon formation. Belcourt and Outon are on a subordinate upland containing a coal of local value, while the Sebree upland extends from Marksville eastward to Green river, showing outcrops, both north and south, of coals No. 9, No. 11, and No. 12; the latter also underlie nearly all of the lowland occupied by Green river and its tributaries. Still another upland, of moderate relief, stretches across the northern end of the county. These uplands are separated by Deer creek, Graves creek and the Green river. Between the Dixon and Sebree uplands is the Rough creek uplift, along whose course the Lockhart-Leitchfield, the Caseyville, and higher formations are exposed.

The relationship of lowland and upland belts to the coals and formations here described should prove a helpful guide in the location of coal beds.

STRUCTURE.

The general or broad structural features of the county are simple. The rocks of all the county, except a strip a few miles wide east and west across its northern end, lie in a broad synclinal trough. The axis of this trough has a general northwest-southeast course and it runs roughly through the Luzon-Dixon-Mt. Gilead school region, coinciding in a general way with the axial line of the Dixon upland.

From the Tradewater and beyond the rocks dip northeastward in this axial line at a rate that generally runs from two to four or five degrees. This dip is somewhat greater in the western part of the county, about Wheatcroft and Clay, than farther east about Providence.

The axial position is not sharply compressed, but the bottom of the trough is broad and fairly flat. The trough is deeper in the Mt. Gilead region than in the Dixon region.

On the northeast the rocks dip southwestward generally at a somewhat higher angle, especially as one nears the Rough creek anticline, where dips of eight to twelve or fifteen degrees are not uncommon, while locally dips may go much higher, though high dips, when traceable in surface exposure, are found to flatten out very rapidly and hence do not involve a great thickness of rocks.

The northern edge of the structural basin passes east through Tilden, and the crest of the Fulcher and Melton hills and of the Sebree hills, or delimited by the Rough creek anticline. This basin might be called the Webster syncline, if a name for it became desirable.

The Sebree Anticline. On the northeast side of the broad basin above described, the rocks generally rise until they are broken sharply off by a fault line along the Rough creek anticline. From Marksville east to Green river, however, the rocks rise to an anticlinal crest and then pitch down on the north side before they are broken off by the great fault. They thus form a long, narrow anticline with the rocks strongly arched, but not badly crushed or broken along its axis. This anticline plunges down and dies out just north of Marksville at its west end. About a mile east or southeast of Sebree it also plunges down for some distance, but farther east the axis becomes horizontal again and it leaves the county at Steamport Ferry still as a pronounced anticline. The highest point along the axis of this anticline is in the hill about half a mile southwest of Sebree Springs, where the structure is somewhat domed. The elevation of this dome has been great enough to bring the top of the Caseyville conglomerate above drainage level there, where it forms the cliffs about Sebree Springs.

The Rough Creek Anticline. This disturbance enters the county on the Union county side near Givens and pursues a somewhat zig-zag course through Tilden, the Fulcher and Melton hills, the northern part of the Sebree hills, through Sebree to Green river about half a mile south of Eastwood ferry, where it passes into McLean county.

This faulting was caused by an overthrust from the south. In places the rocks broke and those from the south were thrust up over those on the north side of the fault. In other places the faulting was of the block type and small areas, always on

the south side of what may be considered the main line of faulting, were lifted bodily upward several hundred feet. The zigzag course of the fault line across the county is due to the predominance of the block-fault feature. East of Marksville, as has been said above, the faulting has been attended with the development of an anticline on the south side of the general fault line, but even here there is also block faulting and crushing along the fault plane on the north side of this subordinate anticline. In Webster county the term Rough creek *fault* would be more applicable than Rough creek *anticline*.

North of this great fault line the rocks are essentially flat. They do dip to the northwest or west-northwest, but at a very low angle, and they seem to be practically undisturbed on their southern margin even up almost to the very fault plane itself.

(Elsewhere in his report Dr. Glenn calls attention to the fact that "along the Rough creek anticline rocks stratigraphically 2,500 feet or more apart may be found lying side by side. He also observes that minor folds and faults occur in the shales and other rocks, but that they are usually insignificant and unlikely to affect the economic value or workability of the important coal beds in any material way.—C. J. N.)

Economic Geology.

Coal is the only mineral resource at present developed. There are a number of seams of much economic importance in the county.

In the southwestern part of the county the lowest of these seams is not exposed at the surface, but may be reached by shaft along the Tradewater river in the general vicinity of Blackford. This seam is the Bell coal. Its thickness and quality are not known in Webster county, but its outcrop down the Tradewater makes it probable that workable areas may be found by boring in this county.

Coal No. 5 of Owen, now generally called No. 6, is workable along its outcrop practically across the entire southwestern end of the county. This outcrop is at or near the foot of the steep scarp overlooking the Tradewater lowland and runs, as has already been said in the topographic section of this report, from Sullivan to Yarbro. This coal is mined for local use at sev-

eral country banks between Golds and Rice's mill. It is solid and about 46 inches in thickness. Over it there are 3 to 5 feet of black shale, separated from the coal by a highly calcareous layer three to six inches thick and filled with marine fossils. This is very characteristic of this coal in this region.

The dip of the rocks northwestward into the Webster synclinal basin soon carries this No. 5 coal too far below drainage to permit of its being worked at present, and when these rocks again rise to the surface in the Sebree region this coal has thinned until it is no longer workable, and, indeed, is not identified with perfect certainty, though it seems probable that it is the second thin coal beneath the Sebree sandstone there.

Coal No. 6, now generally called No. 7, lies close beneath the scarp-making Sebree sandstone. It is nowhere known to be thick enough to work in the southwestern part of the county, though attempts have been made to work it at several places southwest of Providence, where it is somewhat thicker than usual, but is very dirty and varies greatly in section in even a few yards. In the Sebree region it is most probably the coal that years ago was opened at country banks at a number of places in the hills two to three or four miles southwest of Sebree. It is characterized by its position close beneath the scarp of the Sebree sandstone and by being underlaid by 3 to 6 feet of gray siliceous fireclay filled with narrow strap-shaped plant impressions.

The next coal of value is No. 9. This is the most uniform in presence, thickness, and good quality of all the coals of the county and is, all in all, the most valuable one.

It is without parting, is very uniformly 56 to 58 inches thick, and has a massive black shale roof that everywhere contains concretions of iron sulphide or iron carbonate popularly known as "niggerheads."

The quality is good and this coal is actively mined on a commercial scale at numerous points on its southwestern outcrop, from Wheatcroft, or west of there, to Providence. In a broad area in the central part of the Webster synclinal basin this coal, as well as coals No. 11, No. 12, and No. 13 above it, are all too deep to be mined at present, though the day can not be far distant when it will become practicable to reach them by shaft.

On the northeast side of the basin, coal No. 9 rises to the surface near Marksville, where it is now mined at the Spark or Woods mine, and has been mined at a number of places east of there in the vicinity of Ortiz.

North of the Rough creek anticline No. 9 coal is everywhere present in Webster county, except where the old deep valley of Green river has cut it out. It is mined by shaft at Sebree.

Ninety to a hundred feet over No. 9 is generally found another coal, No. 11, that is comparable to No. 9 in commercial value and is likewise extensively mined. No. 11 is, however, variable in thickness and liable to be found absent in places so that it is not reliable a coal as No. 9. One intending to develop it should very thoroughly prospect the area with a core drill before purchase. This coal is absent for several miles along its outcrop horizon in the Clay neighborhood. The gap extends from the old Toga mine near Wheatcroft to near the Lever mine some two miles northwest of Providence.

In the Sebree region coal No. 11 is usually partly or entirely absent.

It is characterized most readily by lying close beneath a limestone that everywhere contains fusulinas. This coal also contains everywhere a band of clay, usually about two inches thick and known as the "blue band." The thickness will vary from 5 to 7 feet. Between the coal and the overlying limestone there may be some inches of black slate, or soft clay, or "gob." The limestone forms an excellent roof.

Coal No. 12 lies close above the limestone over No. 11 coal, but is rarely thick enough or regular enough in Webster county to be prospected. On the Frank Sanders place, two miles west of Sebree, it has been mined as a country bank. It is not generally regarded as a valuable coal. The Marks coal, mined at Marksville, belongs here. It is pockety in its development there.

Above coal No. 12 at a variable interval of, say, 20 to 40 or more feet, there is found in the region northwest of Clay a valuable coal called by the writer the Baker coal, or coal 13 in numerical order since it is the next coal above No. 12 coal in this region. It seems probable that it is the same as a similar thick and excellent coal known in the region east of Webster

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and if oil has accumulated at any point along the fault it would be in these tilted or dipping rocks on the south side of the fault plane, not in the flat rocks on the north side. The chances would have been greater for striking oil at Tilden if the wells had been drilled half a mile or a mile south of where they were drilled, though even there the chances could not be said to be very favorable.

A description is given in the structural section of this report of an anticline extending east from near Marksville, just south of Sebree, to Steamport Ferry and beyond, and a doming of this anticline was mentioned. This dome has its center about where the highway crosses the hill top a half mile southwest of Sebree Springs, or a few hundred yards east of this road crossing. This dome and the area along or close by on the north or south of the axis of the anticline for a mile or or possibly two miles east of there, and for a similar distance west of there, appear to be the most favorable territory in the county to prospect for oil and gas.

Another almost equally favorable area is the high hill crest near or east of the old McLarty place a mile west of Knob Lick creek, where a slight doming of the axis also occurs.

Shale and Clay.—There is an abundance of shale and clay almost everywhere for brick and tile making and such industries could be developed without limit.

Fireclay.—While tests have not been made, the underclays of several of the various coals, especially that under Owen's No. 6 coal, seem probably to be fireclays and would warrant experimental tests to determine their values.

Building Stone.—The sandstones of the county contain much material that might be used as building stone. The only quarry is the one two miles east of Sebree, where stone is gotten out for local use for foundations and chimneys.

The limestones are sometimes used for rough foundations, though generally little or no attention is paid to their use. They are probably too impure to be used for lime. They could be used to advantage for crushed stone for road building.

Sand.—Sand for local use may be obtained at numerous places along the streams in or at the edge of the uplands, but is absent from the lowlands. In some places the Dixon sand-

stone is disintegrated to a soft, loose mass used for building sand.

Miscellaneous.—In various places small pieces of galena, sphalerite, fluorite, phosphate, pyrite, and siderite may be found in place in the county, but nowhere is there any probability whatever that any of them occur in economically valuable quantities. There are also legends of silver mines supposed to exist, especially in the Sebree hills, and known to the Indians and certain ones of the early settlers. It is needless to say to any one who knows the mode of occurrence of silver that such stories are pure myths; and the most positive assurance may be given to credulous parties, who even now occasionally spend time and money hunting and digging for such mythical hidden wealth, that in such search both time and money are wasted.

SOILS AND AGRICULTURE OF THE EASTERN COALFIELD.

By S. C. Jones.

The area lying within the Eastern Coalfield that is generally refererd to as the "Mounatin Region of Kentucky" represents about one-fifth of the total area of the State, or about 8,000 square miles. It was long looked upon, by those ignorant of its possibilities, as a practically valueless country. In truth, it has been handicapped in the past because of its poor wagon-roads and the lack of railroads, which meant that it was practically shut off from the rest of the world.

But the hills and mountains of this region are rich in fine coals, which offer particular advantages for mining, and in some sections there are vast tracts clothed with valuable timbers. Now, the outside world is demanding both the coal and the timber; consequently many miles of railroad are now under construction, many new mines are being opened and

equipped, and towns are springing up where but a few months ago stood the silent forest. Coal lands that but a few years ago sold for fifty cents to two dollars an acre now bring from twenty dollars to one hundred dollars an acre. The whole "mountain region" is astir. It is doubtful whether there is to be found anywhere in the United States a section of country that is undergoing more rapid development, or one in which wealth is being created more rapidly than in this Eastern Coalfield of Kentucky.

While this section of the State is not what may be termed an agricultural country, the fact that its mining interests are being developed means also the development of conditions favorable for certain phases or types of agriculture.

The soils of the region are derived from sandstones, sandy shales, clays and coals that go to make up the Coal Measures. This soil area, like other great soil areas of the State, presents conditions conducive to diversified soils. They may be divided in a general way into three classes, namely: Those of the ridges, those of the hillsides, and those of the bottoms.

Over the greater portion of this area the ridges are too narrow for any purpose, while near the border of the Coalfield is found more or less ridge land covered with soils varying from sand to sandy loams, or loams underlain with a more clay-like subsoil.

On the hillsides are found loams, sandy loams, and shale or gravelly loams. The soils on the east and north hillsides (those facing the east and north), and those in the coves, are usually deeper than those on the south and west hillsides. The south and west hillsides are regarded better for grass, while the east and north hillsides are regarded better for cultivation.

It will be seen by observing the geological map of the State that streams are numerous in the Eastern Coalfield, along which is found more or less bottom land. The width of the bottoms vary of course with the size of the streams. Along many of the streams are found both first and second bottoms. The first bottom lies near the stream and is subject to overflow, while the second bottom is usually above the overflow line.

In the first bottoms brown sandy loams and loams are found, while in the second bottoms are found silt-loams, loams,

and clay loams of varying color, ranging from gray to yellow and brown. The gray soils are found in the wider bottoms near the base of the hill, and would be greatly benefited by artificial drainage. No doubt drainage would greatly benefit all of the second bottom soils.

The future for the soils of this section of the State lies in the development of property, horticulture, grazing, truck-gardening, and the production of poultry.

There are large areas of rough sandy loam in parts of this region that are fit only for forestry. Such areas are usually found along the dividing ridges between the main water ways. Many of these areas have already fallen into the hands of companies that are handling the forest with more or less care, while as a rule the forest belonging to the individual is being rapidly destroyed.

It is perhaps safe to say that there is a greater future for horticulture in Eastern Kentucky than for any other phase of agriculture. While it is true that the large fruits, such as apples, peaches, and pears, are often damaged by late freezes and frosts, yet if the proper varieties were grown and the orchards properly cared for no doubt this damage could be materially decreased. Grapes and other small fruits appear to do especially well when given attention.

On the hillsides containing the loamy soils or soils of more clay-like nature, and even on the sandy soils, such grasses as orchard grass, red top, English blue grass, and even Kentucky blue grass thrive well when given favorable opportunities. The great reason for failure in growing grass is that the land is corned to death before an attempt is made to produce grass. When sown in new land that has been well cared for, success usually results. Japanese clover grows wild and now is the chief grass for pasture.

Sheep will no doubt be the most profitable animal for this country, especially where the more important breeds take the place of the mountain sheep.

With the increase in the mining population the bottom lands will naturally be converted into truck gardens. Much of the bottom land has been cultivated in corn year after year for the last seventy-five or hundred years, and is now badly

worn, especially that lying above the overflow line. The overflow land is practically as fertile as when first cultivated.

The chemical analyses have not yet been made of the soil samples collected from the Eastern Coalfield. The second bottoms that have been so long under cultivation will doubtless be found to be decidedly acid when analyzed.

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